CHAPTER 7

HYDROLOGY

(R645-301-700)

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HYDROLOGY

7.10 Introduction

This chapter presents a description of the hydrologic consideration for permitting of the Crandall Canyon Mine operations. The information in this chapter was provided by the staff of the applicant and by various consultant firms as noted under specific sections. Conclusions drawn herein are based upon detailed field reconnaissance and spring/seep surveys of the area, limited exploratory drilling and published hydrologic information on the area.

7.11 General Requirements

This chapter presents a description of:

- existing hydrologic resources
- proposed operations and the potential impacts to the hydrologic resources
- methods of compliance with design criteria and performance standards
- hydrologic reclamation plans for the Crandall Canyon Mine operations

7.12 Certification

All maps, plans and cross-sections presented in this chapter which deal with the design of facilities or the determination of watershed characteristics have been certified by a professional engineer.

7.13 Inspection

Impoundments included in the runoff control plan will be inspected as described in Section 5.14 of this application.

7.20 Environmental Description

This section presents a description of the hydrologic resources within the Crandall Canyon Mine permit area.

7.21 General Requirements

This section presents a description of the hydrologic resources within the Crandall Canyon Mine permit area.

7.22 Cross Sections and Maps

Figures 7-1 through 7-14 and Plates 7-1 through 7-5 of this chapter depict existing surface and groundwater occurrences within and adjacent to the Crandall Canyon Mine permit area. These figures also illustrate the topography, streams, springs, wells, water monitoring locations, and other hydrologic design information pertinent to the Crandall Canyon Mine.

7.23 Sampling and Analysis

All water samples are collected and analyzed according to methods in either the "Standard Methods for the Examination of Water and Waste Water" or the 40 CFR parts 136 and 434.

7.24 Baseline Information

7.24.1 Groundwater Information

This section is a comprehensive view of the groundwater hydrology for the Crandall Canyon Mine permit and surrounding area.

Scope

This section presents discussion of groundwater conditions within and adjacent to the permit area, which consists of lease areas SL 062648 and U 054762, the right-of-way, State leases ML21568 and ML21569 (Plate 7-12). Conclusions drawn herein are based upon detailed seep and spring surveys of the area, limited exploratory drilling, and the results of groundwater investigations conducted by others in the region of the mine.

Methodology

Seep and spring surveys were conducted in 1985, 1987, and 1989 through 1991, within an area that extended approximately one mile north, west, and south of the boundaries of the permit area. The study area for the survey was bounded by Huntington Creek on the east, the east-west ridge between the North Fork of Horse Canyon and the South Fork of Huntington Creek on the north, Bald Ridge and Bald Mountain in Scad Valley to the west, and Mill Fork on the south.

An aerial reconnaissance of the survey area was initially conducted to provide an indication of spring locations and site accessibility. The area was then traversed on foot to allow springs and seepage points to be precisely located, examined, and sampled.

Geologic conditions at all seeps and springs were noted in the field, including lithologic and structural controls and the geologic formation from which the seepage issued. Signs of usage were also noted. The flow rate was visually estimated and (if sufficient water was present) a sample of the water was collected. The temperature of the water issuing from the spring was measured at the site. All samples were subsequently analyzed in the field for pH and specific conductance.

Hydrologic characteristics of the North Horn, Price River, Castlegate, and Blackhawk Formations are reviewed in this section. Locations of seeps and springs monitored during 1985, 1987, and 1989 through 1991 are shown on Plate 7-12. The geologic occurrence and use of seeps and springs is found in Appendix 7-16. Flow rate and temperature measurements appear in Appendix 7-17. Specific conductivity and pH measurements are found in Appendices 7-18 and 7-19 respectively. Field water-quality measurements are summarized in Appendix 7-20. Laboratory analytical reports for groundwater collected from the eight quarterly sampled seep/spring locations are contained in Appendix 7-39.

Regional groundwater conditions were determined from a review of available literature. Where appropriate, conclusions drawn from investigations elsewhere in the region were used to determine approximate local conditions.

Regional Groundwater Hydrology

Six formations outcrop in the Mine Permit Area (Plate 6-1). According to Doelling (1972), the Masuk Shale Member of the Mancos Shale (Km on Plate 6-1) is a light gray to blue-gray marine sandy shale in the mine vicinity. This unit is exposed at the mouth of Crandall Canyon and in adjacent areas along Huntington Creek. The Masuk Shale Member yields water locally to seeps and springs but does not serve as a regionally important aquifer (Danielson et al., 1981).

The Star Point Sandstone (Ksp) is predominantly a light-gray massive sandstone with minor interbedded layers of shale and siltstone near its base (Doelling, 1972). In the vicinity of the mine, the Star Point Sandstone is 350 to 450 feet thick. The Star Point serves as an important regional aquifer (Danielson et al., 1981), yielding water to several minor and some major springs where fractured and jointed.

The Blackhawk Formation (Kb) is the principal coal-bearing unit in the region (Doelling, 1972). This formation consists of interbedded layers of sandstone, siltstone, shale, and coal, and reaches a thickness of about 1000 feet in the mine area. The principal coal seam (the Hiawatha seam) is present near the base of the formation. The formation yields water to springs and coal mines when fractured. Where it is locally interbedded with the Star Point Sandstone, the lower portion of the Blackhawk Formation is considered an aquifer (Danielson et al., 1981).

The Price River Formation overlies the Blackhawk Formation and consists of the basal tan to brown cliff-forming Castlegate Sandstone (Kc) and the slope forming Upper Price River Member (Kpr). Fluvial sandstones of the Castlegate are massive and medium- to coarse-grained. In the area of the mine, the Castlegate is approximately 200 feet thick. The Castlegate yields water locally to seeps and springs but does not serve as an important regional aquifer because it is commonly drained within short distances from its recharge area due to deeply incised canyons (Danielson et al., 1981).

The Upper Price River Member (Kpr) consists predominantly of friable calcareous sandstone interbedded with pebbly conglomerates and shales. It forms steep receding slopes and reaches a maximum thickness of about 600 feet in the mine areas (Doelling, 1972). This formation yields water locally to seeps and springs (Danielson et al., 1981). However, like the Castlegate Sandstone, deeply incised canyons in the area prevent the Upper Price River Member from being an important regional aquifer.

The uppermost formation that outcrops within the permit area is the North Horn Formation (Tkn). This formation consists of interbedded limestones, sandstones, and shales (Doelling, 1972). Due to high topographic presence but limited aerial extent near the mine area, the North Horn Formation in the vicinity of the permitted and proposed lease areas serves primarily as a recharge unit to underlying formations rather than as an important source of water itself.

Investigations by Danielson et al. (1981) indicated that most, if not all, groundwater in the region is derived from snow melt. Recharge tends to be limited in areas underlain by the Price River Formation and older rocks (relative to recharge in areas underlain by younger rocks) due to slope steepness and relative imperviousness (both of which promote runoff rather than infiltration of snow melt).

Detailed potentiometric surface data are not available for the region surrounding the permit area. However, the deeply incised canyons interrupt the flow of groundwater in much of the area. Danielson et al. (1981) suggest that groundwater generally moves from high areas of recharge to low areas of drainage, principally along stream channels. This flow pattern is altered locally where geologic structure plays a dominant role.

The predominant chemical constituents in most springs in the region are calcium and bicarbonate (Danielson et al., 1981). Dissolved solids concentrations generally range from about 50 to 750 milligrams per liter. Regionally, the concentrations of major dissolved constituents in water from individual geologic units is highly variable, due to the complex lithologic nature of the area (Danielson et al., 1981).

Mine Plan Area Aquifers

Results of the seep and spring inventories conducted in the study area were submitted previously to DOGM (EarthFax Engineering, 1985a, 1985b). Locations of the seeps and springs discovered during the inventories are shown on Plate 7-12. Data collected during the inventories are included in Appendices 7-16 through 7-20.

Approximately 60% of all the seeps and springs found during the early-season surveys had flows of one gallon per minute or less (Appendix 7-17). These flows typically decreased by the time of the late-season surveys, with most of the low-flow sources issuing only as seeps or being dry. The majority of seeps and springs issue from bedding planes separating porous sandstones or fractured zones from underlying low-permeability siltstone and shale beds.

The occurrence of groundwater at Trail Mountain (Lines, 1985) is very similar to that at Crandall Canyon. The major water bearing unit at both mines is the regional Blackhawk-Star Point aquifer. The Trail Mountain Mine is overlain by perched aquifers in the Blackhawk, Castlegate, Price River, and North Horn Formations; these perched aquifers are separated by unsaturated zones (Lines, 1985). Seep and spring survey results at Crandall Creek also reveal the presence of perched aquifers in the same formations. As at Trail Mountain, this perching occurs where more-permeable strata overlie less- permeable strata (Lines, 1985; Appendix 7-16).

The distribution of seeps and springs among the formations present at both the Trail Mountain (Lines, 1985) and Crandall Canyon (Appendix 7-16) mines is very similar. At both mine areas the largest percentage of seeps and springs are found in the North Horn and Price River Formations. Similarly, in both mine areas the smallest percentage of seeps and springs are found in the Castlegate Formation.

The low flow rates from most of the seeps and springs emitting from the Blackhawk Formation (Appendices 7-16 and 7-17) result from the low hydraulic conductivity of the formation where it remains unfractured. Laboratory permeability data from a core sample taken in T17S-R6E-Sec27 at Trail Mountain indicate an average horizontal hydraulic conductivity of 1.3×10^{-2} feet per day, and an average vertical hydraulic conductivity of 3.8×10^{-3} feet per day for sandstone units of the Blackhawk Formation (Lines, 1985). Shale and siltstone samples of the Blackhawk Formation have maximum horizontal and vertical hydraulic conductivities of only 1.0×10^{-7} and 1.2×10^{-6} feet per day, respectively (Lines, 1985). These low hydraulic conductivities of the shales and siltstones indicate that these finer-grained sediments within the Blackhawk serve as barriers to the downward migration of water. As a result, water recharge into the Blackhawk, either from adjacent formations, snow melt, or rainfall, is allowed to percolate vertically through sandstone beds until a siltstone/shale bed is encountered at which time the water is forced to travel laterally along the bedding plane to the surface. Similarly, the majority of the seeps and springs in the Castlegate, Star Point and North Horn Formations observed in the field surveys in Crandall Canyon also issue from bedding planes. Due to the presence of these vertical permeability barriers, the aquifers in the North Horn, Price, River, Castlegate, as well as in the upper portions of the Blackhawk Formations are perched, with no direct communication to the underlying regional Blackhawk-Star Point aquifer. Consequently, dewatering of the Blackhawk-Star Point aquifer resulting from mining the Hiawatha Coal of the Blackhawk Formation has little potential of affecting seeps and springs in the area (Lines, 1985).

Most of the seeps and springs in and around the state lease areas, right of way, and the LBA leases principally drain aquifers in the North Horn and Price River Formations (Appendix 7-16). The North Horn and Price River Formation aquifers lie 470 to over 2410 feet above the top of the Hiawatha Coal Seam and are found along bedding planes and appear perched with no direct hydraulic connection to the potential mine workings in the Hiawatha coal bed. As a result, mine dewatering is anticipated to have minimal, if any affects on these seeps and springs.

Lesser numbers of seeps and springs drain the perched aquifers in the Blackhawk Formation and lie approximately 420 or more feet above the potentiometric surface of the regional Blackhawk-Star Point aquifer. With no direct communication to the underlying regional aquifer these water sources should not be affected by mine dewatering.

Seeps and springs northwest of the lease areas and right of way discharge from the North Horn Formation or alluvium covering the North Horn Formation in Little Joe's Valley. In contrast to other seeps and springs in the study area, flows from many of these water sources increased substantially between the spring/early summer surveys and the fall surveys (Appendix 7-17). This anomalous water flow trend is attributed to three factors. First, recharge from the Joe's Valley Fault Zone. These water sources lie in a linear trend parallel to the fault zone, directly along or west of Indian Creek which also follows the trace of the fault zone. Secondly, recharge from water in the colluvium and alluvium on the west-facing slope of East Mountain flows downhill toward Little Joe's Valley and discharges into the valley alluvium. The relatively late arrival of this water is due to the lag time as this snow melt-derived water travels through the soil to the valley floor. Thirdly, these seeps and springs in Little Joe's Valley lie in a different drainage basin than those in the rest of the study area, a drainage basin which has a contrasting flow pattern to that present in the Huntington Creek tributaries on the east-facing slopes of East Mountain.

During the period of March and April 1987, a monitoring well (MW-1) was installed at the Crandall Canyon Mine in the location indicated in Plate 7-13. This well currently serves as a water supply well for the mine. MW-1 was drilled using air-rotary methods to a total depth of 375 feet, and encountered Star Point Sandstone through its entire depth (Figure 7-1).

The driller indicated that the formation was relatively homogenous except in the zone from 290 to 335 feet, where the sandstone became coarser. It is from this zone that the well is producing water, with water first being encountered at a depth of about 315 feet. The static water level approximately one week after completion of the well was at a depth of 186.1 feet below ground surface, indicating the presence of a significant upward pressure component (approximately 130 feet) within the saturated zone.

After completion of the well, a slug test was performed on the well to determine the approximate hydraulic characteristics of the Star Point Sandstone at the mine site. This test was performed by inserting approximately 10 feet of drill stem below the water surface and allowing the water level to stabilize over a period of 3.75 hours. Although water level recovery was measured during this period, the data are not adequate for slug-test analysis since the drill stem was present within the zone of influence of the injection test, thus displacing additional water during the recovery period.

Following stabilization of the water level, the drill stem was rapidly removed from below the water level and the resulting recovery to static conditions was measured for a period of more than 2 hours. Data collected from this test have been provided to the Division in a letter addressed to Mr. Dave Cline from Richard B. White of EarthFax Engineering, Inc. and dated April 30, 1987. Data collected for the first 700 seconds of the test are provided in Figure 7-2.

In-mine monitoring wells MW-4 and MW-5 were installed, completed, and developed in January, 1992. Monitoring well MW-3 is located in an area that was sealed in 1979 and is now inaccessible. Water-level data collected in January, 1992 from MW-2, MW-4, and MW-5 were used to produce the potentiometric surface map depicted on Plate 7-13. Slug test were also performed on MW-4 and MW-5.

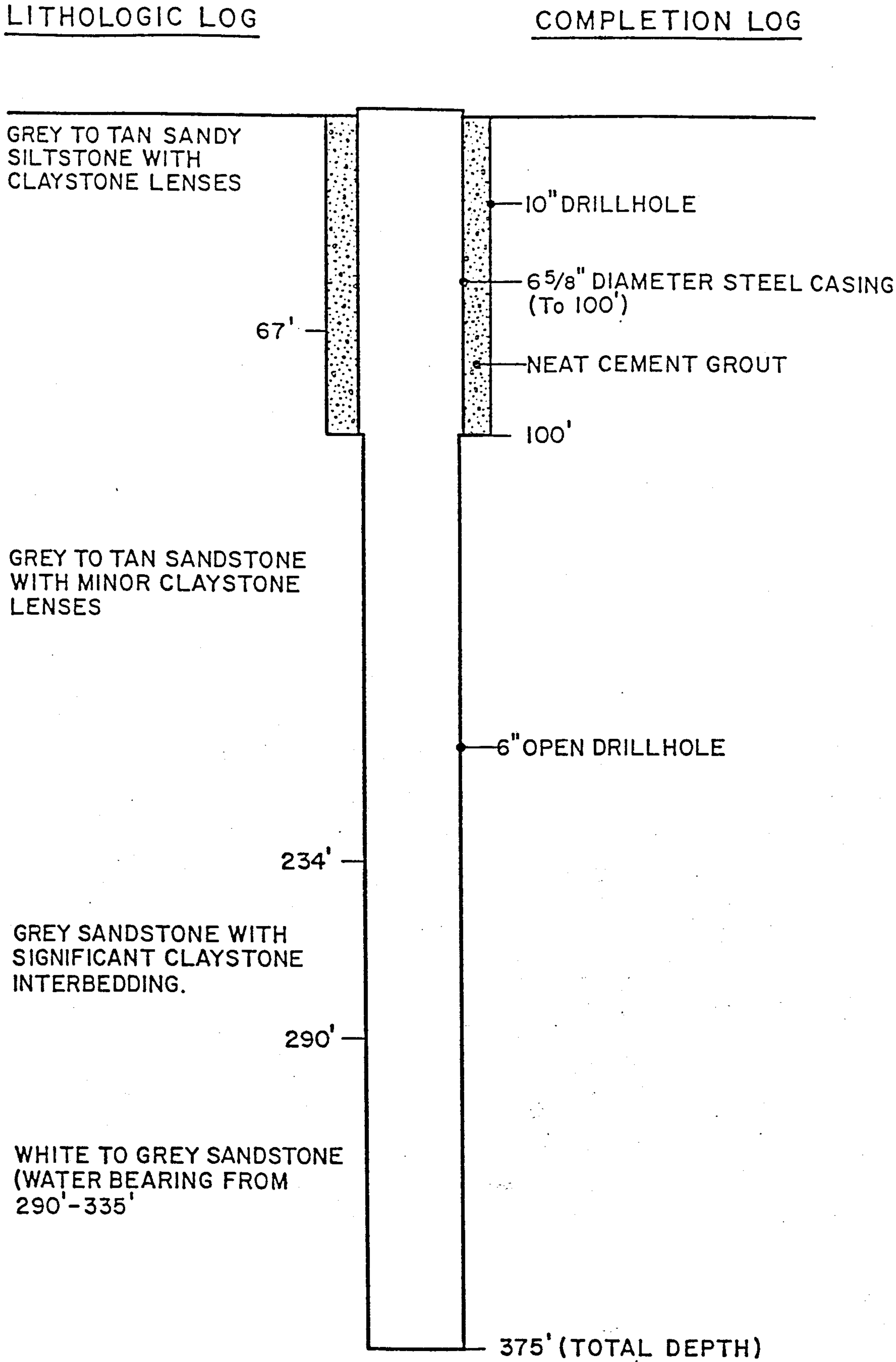


Figure 7-1. Well completion and lithologic log for MW-1.

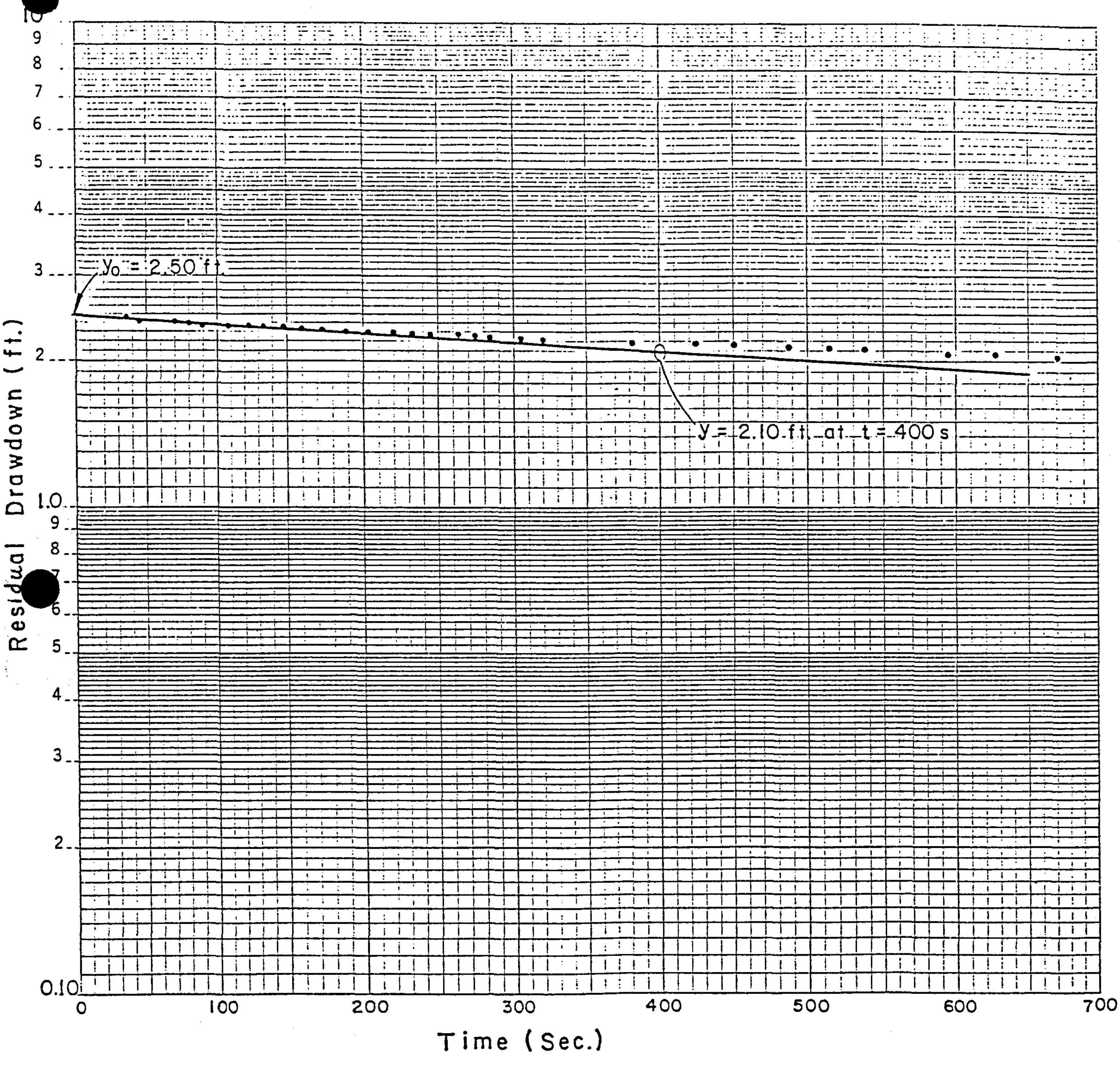


Figure 7-2. Results of slug withdrawal test in MW-1.

The slug test data were analyzed using a method developed by Bouwer and Rice (1976). According to this method:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L} \frac{1}{t} \ln \frac{y_o}{y_t} \qquad (7\text{-}1)$$

where

K	=	hydraulic conductivity (feet per day)
r_c	=	radius of the casing (feet)
r_w	=	radius of the well
L	=	length of the screened section (feet)
t	=	time since test began (seconds)
y_o	=	maximum drawdown during test of drawdown immediately following slug injection or withdrawal (feet)
y_t	=	drawdown at time t (feet)

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(H/r_w)} + \frac{C}{L/r_w}\right]^{-1}$$

where

H	= depth from static water level to the base of the producing zone
C	= a dimensionless coefficient as a function of L/r_w obtained from Figure 3 of Bower and Rice (1976, p.426)

For the slug test conducted at MW-1,

r_c	=	r_w = 0.25 ft (hole radius of 3 inches)
L	=	335-290 = 45 ft (length of the producing zone according to the driller's records)
H	=	335-187 = 148 ft (distance between the static water level and the base of the producing zone
y_o	=	2.50 ft (see Figure 7-2)
y_t	=	2.10 ft at t = 400 s (see Figure 7-2)

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(148/0.25)} + \frac{6.6}{45/0.25}\right]^{-1} = 4.8$$

By means of equation (7-1) and these data, a hydraulic conductivity of 0.1 foot per day was calculated. Assuming that the 45-foot producing zone accounts for the entire thickness of the aquifer at the location of MW-1, this value converts to a transmissivity of 4.5 square feet per day. Slug tests from MW-4 and MW-5 were analyzed using the same equation and the hydraulic conductivity for MW-4 was determined to be 0.6 foot per day (2.3 square feet per day) and 2.5 foot per day (13.0 square feet per day) for MW-5. The data sheets for MW-4 and MW-5 slug tests are included in Appendix 7-24. These determined transmissivities are similar to those measured by Lines (1985) from pumping tests performed in the Star Point Sandstone near Trail Mountain approximately 10 miles southwest of Crandall Canyon.

According to Danielson et al. (1981), the flow of groundwater in the region is generally from high-elevation recharge areas toward major canyons. As shown on Plate 7-13, the piezometric surface in the Star Point Sandstone aquifer is below the mine floor throughout the current workings. Minor inflow to the existing mine workings has been from the roof only, even though the floor of the mine within the western third of the mine area is below the elevation of Crandall Creek. In addition, as noted above, the depth to groundwater at the mouth of the mine (at MW-1) is approximately 186 feet below ground surface. Thus, it is reasonable to assume that groundwater within the Star Point Sandstone beneath the mine does not discharge into Crandall Creek.

Although the regional stratigraphic dip is to the west (see Chapter 6), strata locally dip to the southeast. As shown on Plate 7-13, the direction of groundwater flow in the Star Point Sandstone beneath the mine is eastward, from East Mountain to Huntington Canyon.

In the area of Trail Mountain (located approximately 10 miles southwest of Crandall Canyon) the hydraulic gradient of groundwater in the Star Point Sandstone varies from about 0.11 foot per foot in the recharge area near the ridge line to about 0.03 foot per foot in the discharge area in Straight Canyon (Lines, 1985). Due to the similarity of the geologic conditions in the two areas (Waddell et al., 1981), similar hydraulic gradients are expected in the East Mountain recharge area and Huntington Canyon discharge area, respectively.

Usage of seeps and springs within the survey area is confined to deer, elk, and other wildlife and limited usage by livestock. None of springs appear to have been improved for human consumption. As would be expected, wildlife usage of the springs is most abundant where flows are greatest and the source is most accessible.

Data contained in Table 7-1 indicate that the specific conductance of water issuing from springs in June generally increased with increasing stratigraphic depth. This is in agreement with the findings of Danielson et al, (1981). Springs issuing from the Price River Formation typically had a specific conductance during the June survey that varied from 150 to 450 umhos/cm at 25°C while those issuing from the Blackhawk Formation and Star Point Sandstone had a specific conductance varying from 500 to 1000 umhos/cm at 25°C. This increase in specific conductance is indicative of leaching of minerals by the groundwater as it flows through increasing distances of bedrock to the lower stratigraphic positions.

The pH of water issuing from springs in the survey area showed no trends within or between formations. Values varied from 6.80 to 8.57, averaging 7.74. Hence, spring water in the study area is slightly alkaline.

In those springs with sufficient water to sample, pH generally increased slightly between June and October. Increases normally amounted to 0.1 to 0.5 pH unit. Specific conductance showed no consistent pattern between the June and October data, with approximately as many increases as decreases between June and October.

Water temperatures vary widely at the site. In general, temperatures are lowest in springs issuing from fractures and highest in springs issuing from shallow colluvium over bedrock. Low temperatures generally occurred in springs with relatively low specific conductances.

Groundwater Development and Mine Dewatering

Water Supply

As noted previously, a few of the seeps or springs inventoried during the spring/seep surveys have been developed for beneficial use. This development does not include springs issuing from the Star Point Sandstone. No water wells used for consumption by humans or animals, other than MW-1, are known to exist within the study area of the spring inventory. Hence, only minor groundwater development has occurred in the past within the mine plan or adjacent areas.

Appendix 7-43 contains a listing of groundwater rights (and their associated seeps and springs) in and adjacent to the permit area. This data was obtained from the files of the Utah Division of Water Rights in February, 1992. More in-depth information concerning these rights is contained in Appendix 7-1. Locations of these water rights are denoted in Plate 7-14. Appendix 7-43 also shows what groundwater right corresponds to the seeps and springs observed in the field inventories.

Mine Dewatering

An underground water budget (January 15, 1991) appears in Appendix 7-21. Current use of mine inflow is 7.6 gpm. Projected use of mine inflow is 7.9 gpm. The quantity of mine inflow that is lost to evaporation and infiltration are estimates based on experience at other mines, and the infrequent need to discharge into Crandall Creek.

Although worst-case estimates of mine inflow are greater than the present inflow rate, the actual inflow rate to be encountered is unknown. In order to effectively treat mine inflow an additional sump and pump house will be built in the southeastern corner of Lease ML-21569 (Appendix 7-22). This new sump will be equipped with a Worthington pump capable of pumping 150 gpm at 400 psi. This proposed sump will serve as the primary treatment facility for mine inflow, as well as the active water supply for mining operations. The existing sump will be maintained as a secondary water treatment facility. If discharge is required, water to be discharged will be initially treated in the proposed sump in Lease ML-21569, them pumped to the secondary (presently existing) sump, prior to discharge into Crandall Creek.

In the event mine inflow rates exceed the capacity of these treatment facilities to treat the mine inflow to meet the discharge limit criteria outlined in the NPDES Permit, Genwal commits to modifying these treatment facilities and/or constructing additional facilities in order to ensure compliance with the NPDES Permit. Treatment facilities to be considered include enlargement and/or construction of additional underground sumps and/or surface settling ponds. If excessive water volumes are encountered the use of flocculants and gel-logs will be considered as stopgap measures until more permanent treatment facilities are in-place.

Present inflow into all of the Crandall Canyon mine workings total no more than 100 gallons per minute. The vast majority of this inflow is occurring in the old mine workings (Leases U054762 and SL-062648). Only negligible mine inflow has been encountered in the right-of-way and State Lease ML-21569. Currently, water used in mining operations is being pumped to State Lease SL-21569 from the sump in the old mine workings. All inflow water is used in underground mining operations.

Effects of Mining Operation On Groundwater

Mine dewatering (resulting in removal of water from the aquifers) is the primary mechanism by which the groundwater system may be impacted. As previously stated, it is believed that the water emitting from seeps and springs in State Leases ML-21568 and ML-21569, as well as in the surrounding areas, originate from perched aquifers with no direct communication with the regional Blackhawk-Star Point aquifer. Thus, dewatering resulting from mining the Hiawatha Coal of the Blackhawk Formation has little potential for impact. This observation is in agreement with conditions present at Trail Mountain as reported by Lines (1985).

As previously stated, average horizontal and vertical hydraulic conductivities in the Blackhawk Formation are $1.3x10^{-2}$ feet per day, respectively (Lines, 1985). Blackhawk shales and siltstones have maximum horizontal and vertical hydraulic conductivities of $1.0x10^{-7}$ and $1/2x1^{-6}$ feet per day, respectively (Lines, 1985). Lines (1985) also reports maximum horizontal and vertical hydraulic conductivities for the Star Point Sandstone of $3.1x10^{-2}$ and $1.1x10^{-2}$ feet per day, respectively.

A slug test performed in MW-1, MW-4, and MW-5 (Plate 7-13) revealed a hydraulic conductivity of 0.1 foot per day, 0.6 foot per day, and 2.5 foot per day, respectively, for the Star Point Sandstone (Section 7.1.2.2). These values translates to a transmissivity of 4.5 square feet per day, 2.3 sqaure feet per day, and 13.0 square feet per day for MW-1, MW-4, and MW-5 respectively. These results are similar to those reported by Lines (1985) at Trail Mountain.

A map of the potentiometric surface of the Blackhawk-Star Point aquifer in the permit area appears on Plate 7-13. The average horizontal hydraulic gradient across the permit area is 0.02 foot per foot.

Mitigation and Control Plan

Based on information presented in the preceding section, only minimal impacts on groundwater resources in the permit area may result.

Should it be necessary to develop alternate water supplies due to unexpected diminution or interruption of flows as a direct result of mining activities, the applicant will contact the Utah Division of Wildlife Resources and develop plans to replace water supplies in quantity and quality, on a case-by-case basis. This would be augmented with water currently owned by Genwal Coal Company, and would be a 1 to 1 replacement through wells and diverting underground flows and or other mitigation as to discussions with UDWR.

Currently, treatment of mine water prior to discharge into Crandall Creek includes use of one underground sump. Discharge to Crandall Creek has occurred only 3 times in the last 5 years (NPDES Permit - Appendix 5-14).

7.24.2 Surface Water Information

Scope

This section presents discussion of surface water conditions within and adjacent to the permit area (lease areas SL062648 and U 054762, state leases ML21568 and ML21569, and the right-of-way).

Conclusions drawn herein are based upon a field reconnaissance of the area and a review of published hydrologic information.

Methodology

The U.S. Geological Survey established a gaging station at the mouth of Crandall Creek in 1978. The gaging station was maintained through water year 1984. Data collected from this station were obtained from the Water Resource Division of the USGS in Salt Lake City and used to determine seasonal variations in flows in areas adjacent to the mine plan area.

Regional Surface Water Hydrology

Crandall Creek is an east-flowing tributary of Huntington Creek, one of the major tributaries of the San Rafael River. Huntington Creek had annual flows near Huntington ranging from 25,000 to 150,000 acre-feet during the period of October 1931 through September 1973, averaging 65,000 acre-feet per year (Waddell et al., 1981). Variations in the annual flow of Huntington Creek near Huntington are depicted on Figure 7-6.

Approximately 50 to 70 percent of stream flow in the mountain streams of the region occurs during May through July (Waddell et al., 1981). Stream flow during this late spring/early summer period is the result of snow melt runoff.

The quality of water in Huntington Creek and other similar streams in the area varies significantly with distance downstream. Waddell et al. (1981) found that concentrations of dissolved solids varied from 125 to 375 milligrams per liter in reaches of major streams above major diversions to 1600 to 4025 milligrams per liter in reaches below major irrigation diversions and population centers. The major ions at the upper sites were found to be calcium, magnesium, and bicarbonate, whereas sodium and sulfate became more dominant at the lower sites. They attributed these changes to (a) diversion of water containing low dissolved solids concentrations, (b) subsequent irrigation and return drainage from moderate to highly saline soils, (c) groundwater seepage, and (d)

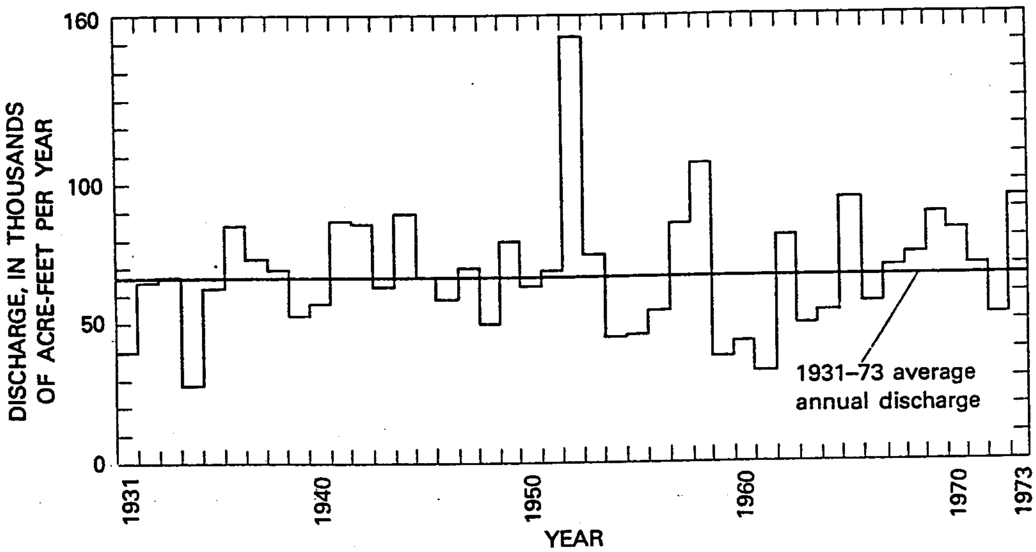


Figure 7-6. Annual discharge of Huntington Creek (from Waddell et al., 1981).

inflow of sewage and pollutants from population centers.

Average annual sediment yields within the Huntington Creek drainage basin range from approximately 0.1 acre-feet per square mile in the headwaters area to about 3.0 acre-feet per square mile near the confluence with the San Rafael River (Waddell et al., 1981). Increases in sediment yield with increasing distance downstream is generally the result of increasing amounts of shale and sandstone in the downstream direction (Waddell et al., 1981).

Mine Plan Area Surface Hydrology

The permit area is drained by a combination of ephemeral, intermittent, and perennial watersheds. These watersheds are steep (with average slopes often exceeding 50 percent) and well vegetated (with percent covers also often exceeding 50 percent).

Flow measurements collected at the U.S. Geological Survey gaging station at the mouth of Crandall Creek, from a flume in Blind Creek, and estimated in Horse Creek are contained in Appendix 7-2. The Crandall Creek data are summarized in Figures 7-7 (monthly flow volumes) and 7-8 (monthly maximum and minimum flow rates) for the period of record (October 1978 - September 1984). Data collection from the Crandall Canyon gaging station was discontinued by the USGS in 1984.

As noted in Figures 7-7 and 7-8, the flow data for Crandall Creek are not complete for the winter months in most years, presumably due to data acquisition problems. Assuming an average flow of 30 acre-feet per month for the period of missing record, the average annual flow for the six-year period of data contained in Appendix 7-2 was 2740 acre-feet.

According to Figure 7-8, maximum flow rates in Crandall Creek normally occur in the months of May or June, while minimum recorded flows occurred during the months of September through November. During the period of record, the maximum recorded daily flow rate has been 88 cubic feet per second (on May 30, 1983). The minimum recorded daily flow rate has been 0.28 cfs (on several days in September 1981) during the same period. Lower minimums may have occurred during the period when data are lacking.

Plan and profile views of Crandall Creek adjacent to the surface facilities are shown on Plate 7-1. Selected cross sections are provided on Plate 7-2. As noted, Crandall Canyon is steep, with channel slopes normally exceeding 5 percent. The channel bottom is approximately 10 feet wide and side slopes are steep (generally greater than 100 percent).

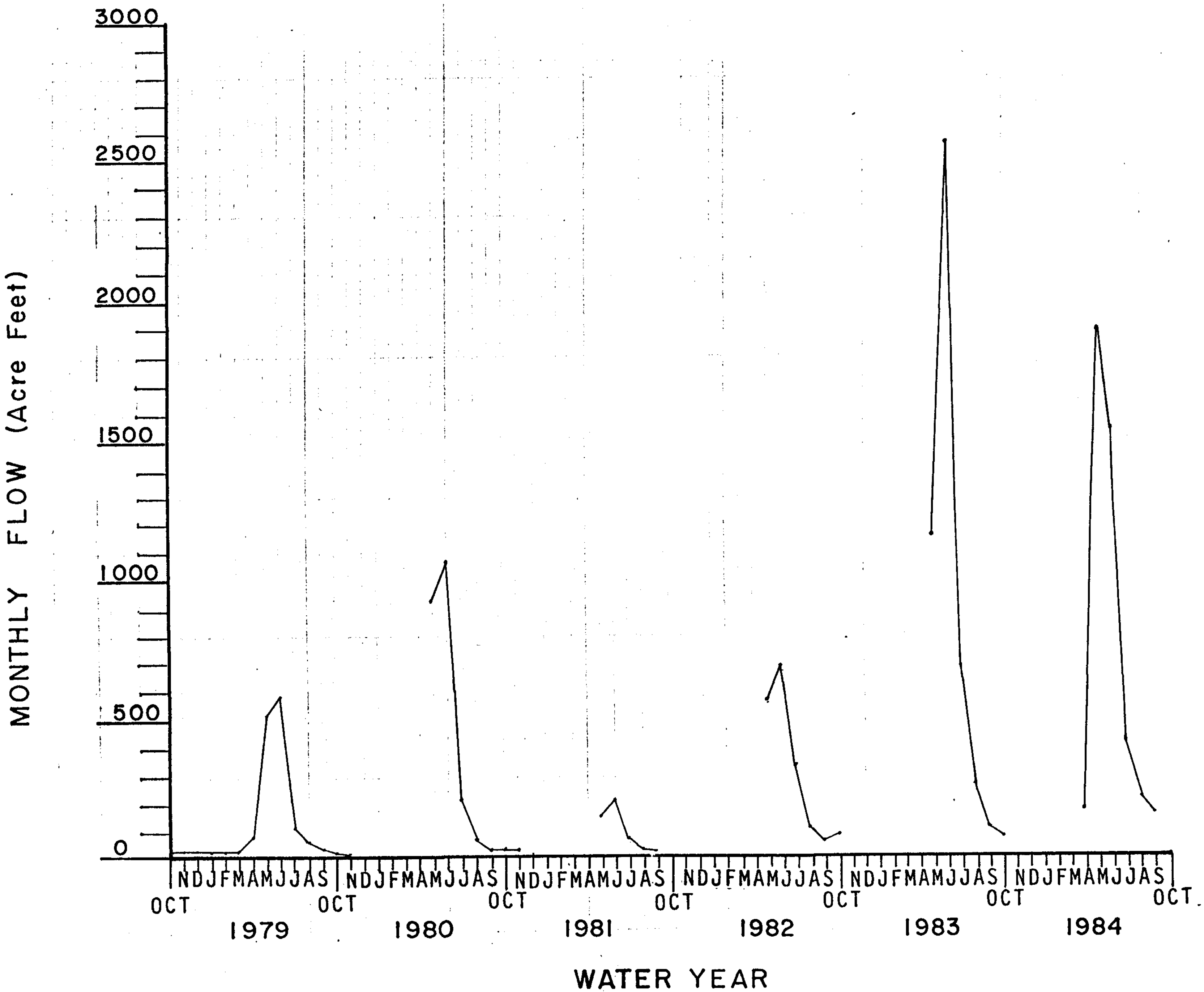


Figure 7-7. Monthly flow of Crandall Creek near Huntington.

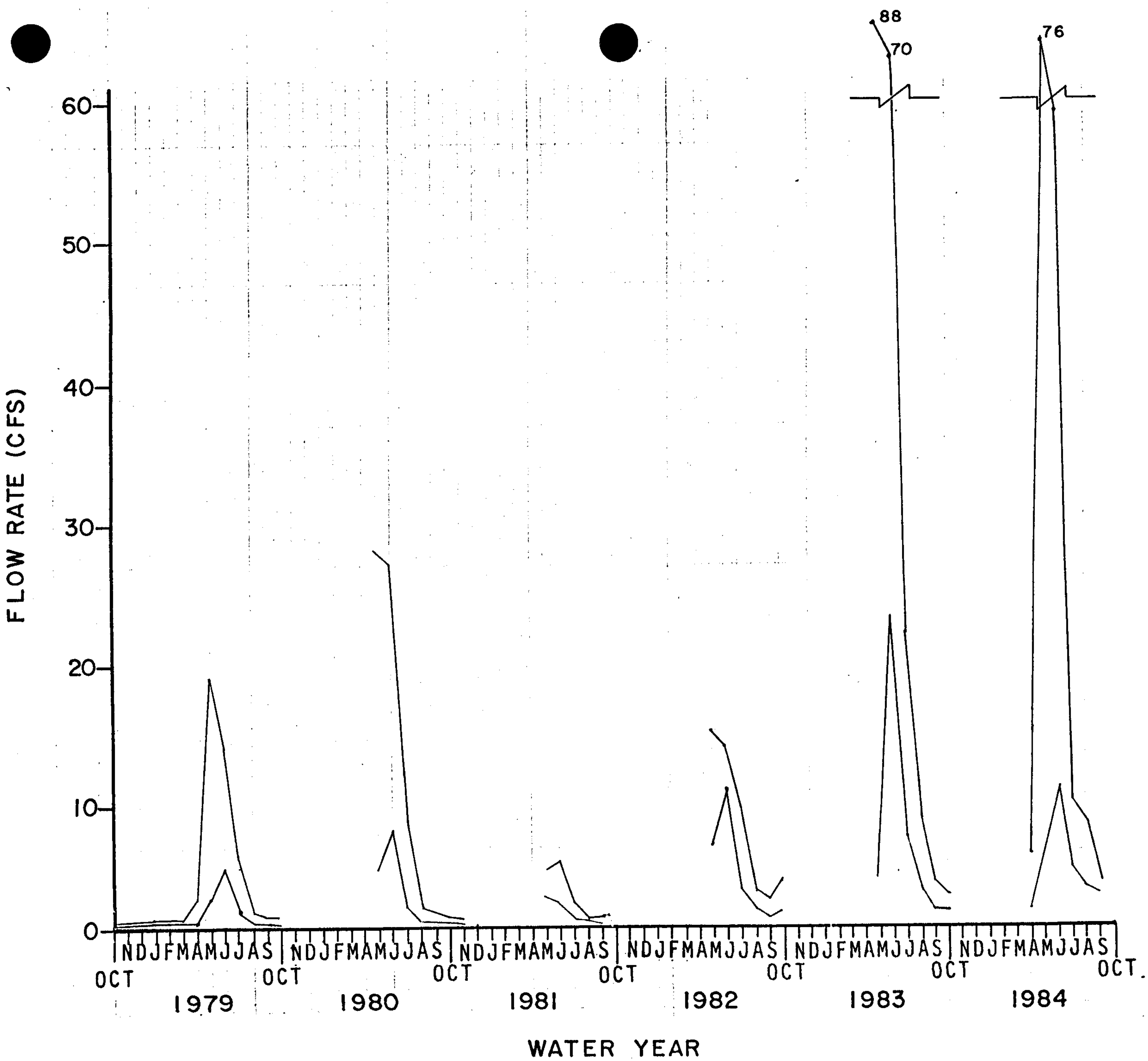


Figure 7-8. Maximum and minimum daily flows of Crandall Creek near Huntington.

Surface water-quality data collected from Crandall Creek by Genwal are contained in Appendix 7-3 and summarized in Table 7-5a. These data, collected between June 1983 and November 1985, indicate that the dominant ions in Crandall Creek are calcium and bicarbonate. Total dissolved solids concentrations in the stream have varied from 180 to 286 milligrams per liter, with lower concentrations normally occurring during the high-flow season.

Total suspended solids concentrations in Crandall Creek have varied during the period of record from <0.5 to 5.0 milligrams per liter (see Appendix 7-3). As expected, the highest suspended solids concentrations generally occur during period of highest flow.

Blind Canyon Drainage

In consultation with the Division of Oil, Gas and Mining, Utah State Lands, the Manti-La Sal National Forest, the U.S. Forest Service Intermountain Research Station, and the U.S. Bureau of Land Management, Genwal Coal Company has committed to partaking in a study by which the pillars beneath the unnamed drainage in Blind Canyon in T15S-R6E-Sec 36 will be retreat-mined as part of a scientific study to determine effects of retreat-mining produced subsidence on watershed erosion and stream flow. This study would monitor the actual affects of mining as proposed in Section 36. The U.S.F.S. Intermountain Research Station's research proposal appears in Appendix 7-25. This research proposal has been developed during close communication between the Intermountain Research Station and Genwal Coal Company. Genwal Coal Company has committed to help finance the U.S.F.S. Intermountain Research Station's study, and perform subsidence monitoring as well as collection of Blind Canyon water quality and discharge data. A timetable of research and mining to be conducted is found in Appendix 7-26. This timetable was developed in consultation with the U.S.F.S. Intermountain Research Station's Principal Investigator, to ensure that baseline data will be collected prior to subsidence within the study area.

As part of an agreement between Genwal Coal Company and the above-referenced parties, pre- and post-mining erosion calculations for the Blind Canyon drainage have been calculated to determine the potential degree of increased erosion. These calculations appear in Appendices 7-27 through 7-38. An overview of the erosion calculations is presented in Appendix 7-39. Final results of these calculations are presented in Appendix 7-38. Drawings applicable to the erosion calculations appear as Plates 7-8, 7-9, 7-10, and 7-11.

Appendix 7-38 results indicate a potential worse-case increase of erosion exiting State Lease ML-21569 (T15S-R6E-Sec 36) onto Manti-La Sal National Forest land to be 0.374 ac-ft. This value is the sum of the SEDROUTE calculations (Appendix 7-37), and the stream bed erosion calculation contained in Appendix 7-38. This worst-case calculation assumes all potentially erodible material is transported onto Manti-La Sal National Forest Service land. The Manti-La Sal National Forest Service desires an equal or greater amount of sediment to be trapped elsewhere in the Manti-La Sal National Forest to offset potential erosion increases that may result from retreat mining of State Section 36. As discussed with the U.S.F.S. Research Station personnel, and officials of the Manti-La Sal National Forest Service, erosion control measures cannot be implemented within the Blind Canyon drainage on the State of Utah or Manti-La Sal National Forest Service lands due to potential impacts on the U.S.F.S. Intermountain Research Station's study. Consultations with Manti-La Sal National Forest Service personnel have revealed that the Forest Service has identified numerous sites within the Manti-La Sal National Forest where erosion control measures are desired. Genwal commits to providing the Forest Service with ten thousand dollars to be used by the Manti-La Sal National Forest at site(s) chosen by, the Forest Service to control this or a greater amount of sediment elsewhere in the Manti-La Sal National Forest. The Manti-La Sal National Forest would be responsible for determining what sediment control measure is to be used, and for implementing and maintaining (if necessary) the control measure. Additionally, Genwal commits to remediating any adverse effects of retreat mining.

Thin-section microscopy and x-ray diffraction analyses of shales obtained from Crandall Canyon Mine overburden reveal the presence of a variety of bentonitic (swelling) clays. Moreover, carbonate cementation characteristics observed in thin-section and at outcrops, as well as groundwater analytical results, suggest pore-fluid chemistries that will promote sealing of subsidence fractures (Appendix 7-41). This appendix also references a U.S. Forest Service study which indicates physical closure of subsidence fractures. The Crandall Canyon Mine overburden mineralogy, as well as physical closure of tension fractures, will aid in the protection of perched aquifers and surface waters.

Surface Water Development and Control

Water Supply

No extensive surface water development has occurred in the mine plan or adjacent areas. Genwal has historically pumped water from the stream near the sedimentation pond for use underground. However, no pumping has taken place over the previous two years. Once the magnitude of the minimum instream flow is established, Genwal agrees to not pump from Crandall Creek at a rate that will cause the instream flow to decrease below the minimum required rate. For the purpose to this determination, flow rates will be measured using the flume at the "Lower Stream Station" indicated on Plate 7-7. No other points of development are known to exist on Crandall Creek or adjacent streams in the immediate vicinity of the

Table 7-5a. Concentrations of Selected Constituents in Crandall Creek.

Constituent	Maximum (mg/l)	Date	Minimum (mg/l)	Date	Mean (mg/l)
Upper Station[a]	60 Samples				
Total Diss. Solids	320	11/24/87	180	4/08/85	255
Total Susp. Solids	1472	5/16/84	0	7/17/86	59.3
pH[b]	8.28	10/29/86	6.75	1/14/84	7.78
Total Iron	0.34	6/28/83	<0.05	Several	0.06
Diss Iron	<0.05	Several	<0.05	Several	<0.05
Total Manganese	0.03	Several	<0.01	Several	0.01
Lower Station[a]	52 Samples				
Total Diss. Solids	323	1/29/86	165	11/07/84	259
Total Susp. Solids	1468	5/16/84	0	7/17/86	57.8
pH[b]	8.66	11/20/86	6.95	11/01/84	7.75
Total Iron	0.25	6/28/83	<0.05	Several	<0.05
Diss Iron	<0.05	Several	<0.05	Several	<0.05
Total Manganese	0.03	Several	<0.01	Several	0.01

[a] See Figure 7-8
[b] In standard pH units

mine plan area.

Genwal, in consultation with the U.S. Forest Service, will determine the appropriate base-line stream flows which should be maintained in Crandall Creek during pumping episodes.

Table 7-6 presents a listing of surface water rights within the permitted and adjacent areas as obtained from the files of the Utah Division of Water Rights in June, 1990. More in-depth information concerning these rights is contained in Appendix 7-1. Listing of these rights are noted on Plate 7-15.

Only one water-supply intake is known to exist on Crandall Creek. This intake is located immediately upstream from the sedimentation pond and is operated by Genwal to obtain water for use at the mine. A search of records on file with the Utah Division of Water Rights and an examination of physical conditions along Crandall Creek and Huntington Creek indicate that no other water-supply intakes exist within one mile from the confluence of the two streams.

7.24.3 Geologic Information

Sufficient geologic information required for Sections 724.310 and 724.320 is provided in Chapter 6 and in this chapter under Sections 7.24.1 and 7.24.2.

7.24.4 Climatological Information

General

The Air Pollution Control Plan has been approved with conditions by the Department of Health letter of February 3, 1992. Fugitive dust control measures to be used in connection with the Genwal Mine facility are included within the remainder of this Section.

Table 7-6. Surface water rights in the Crandall Canyon Mine Permit 4 Area & Adjacent Areas

W.U. Claim No.	Owner	Claim Allotment	Use	Period of Use	Source
93-175	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-181	U.S. Forest Service	(b)	Stockwater	July 1 to Aug 30	Stream
93-182	U.S. Forest Service	(d)	Stockwater	May 21 to Aug 30	Stream
93-183	U.S. Forest Service	(a)	Stockwater	July 6 to Aug 25	Stream
93-184	UT State Lands&Forestry	(c)	Stockwater	Jan 1 to Dec 31	Stream
93-188	U.S. Forest Service	(d)	Stockwater	May 21 to Aug 30	Stream
93-190	U.S. Forest Service	(d)	Stockwater	June 21 to Sept 10	Stream
93-191	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-198	U.S. Forest Service	(e)	Stockwater	July 1 to Sept 10	Stream
93-258	UT State Lands&Forestry	(c)	Stockwater	Jan 1 to Dec 31	Stream
93-336	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-377	U.S. Forest Service	(f)	Stockwater	June 1 to Sept 30	Stream
93-383	UT State Lands&Forestry	(c)	Stockwater	Jan 1 to Dec 31	Stream
93-483	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream

Table 7-6. Surface water rights in the Crandall Canyon Mine Permit 4 Area & Adjacent Areas (Continued)

W.U. Claim No.	Owner	Claim Allotment	Use	Period of Use	Source
93-606	U.S. Forest Service	(a)	Stockwater	June 6 to Sept 25	Stream
93-1180	U.S. Forest Service	(d)	Stockwater	June 21 to Sept 30	Stream
93-1590	U.S. Forest Service	(g)	Stockwater	June 21 to Sept 30	Stream
93-1673	U.S. Forest Service	(h)	Stockwater	June 6 to Sept 20	Stream

(a) Part of water right WUC 93-1403 on Crandall Canyon Allotment
(b) Part of water right WUC 93-507 on Horse Creek Allotment
(c) Part of water right WUC 93-500
(d) Part of water right WUC 93-116 on Gentry Mountain Allotment
(e) Part of water rights WUC 93-193, -198, -201, -1410, -1411, -1412, -1413, and -1414 on Crandall Canyon Allotment
(f) Part of water right WUC 93-377 on Little Joe's Valley Allotment
(g) Part of water right WUC 93-1588 on Trail Mountain Allotment
(h) Part of water rights WUC 93-985, -1632, and -1677 on Joe's Valley Allotment

Existing Environment

Precipitation

Monthly Averages

Jan.	2.90"	Feb.	2.18"	Mar.	2.53"
Apr.	0.72"	May	1.67"	June	0.19"
July	0.96"	Aug.	2.29"	Sept.	0.32"
Oct.	0.40"	Nov.	2.66"	Dec.	3.18"

Yearly Average: 20.00"

Mean Monthly: 1.75"

Temperature

Summer Range: +32 to +90 Degrees Fahrenheit
Winter Range: -10 to +40 Degrees Fahrenheit

Evaporation

Potential evapotranspiration of 18 to 21 inches per year.

Humidity

Normal for elevation in this area.

Wind

Average direction of prevailing winds from west and northwest. The average velocity of prevailing winds representative of the proposed mine plan area is 12 miles per hour as best determined by the Utah State Climatological office.

Effects of Mining Operation On Air Quality

Estimate of Uncontrolled Emissions

The estimate of uncontrolled particulate emissions was determined by the State of Utah Department of Health for a coal production rate not to exceed 1,500,000 tons per year.

Description of Control Measures

Refer to Appendix 4-7 for measures that will be specifically committed to, for implementation. The air quality approval order authorizes the increase in coal production with the conditions noted therein.

Climatological and Air Quality Monitoring

Operator proposes no monitoring plan as the State of Utah, Division of Health proposed on recommendations for monitoring. Refer to letter included as Appendix 4-7.

7.24.5 Supplemental Information

It is not anticipated that any additional information will be required for the PHC, since this is an approved permit; however, additional information may be required to satisfy stipulations from the U.S.F.S. and D.O.G.M.

7.24.6 Survey of Renewable Resource Lands

All renewable resource survey information is included in the Subsidence Control Plan in Section 5.25.

7.24.7 Alluvial Valley Floors

The permit area is located only in upland areas of the Crandall Creek watershed containing a thin veneer of colluvial deposits. As a result, the area is not underlain by an alluvial valley floor.

The area occupied by the surface facilities (adjacent to Crandall Creek) is a steep, narrow canyon with only limited amounts of rocky alluvium. No agricultural activities have been conducted in the area in the past nor will they be in the future due to the limited width of alluvium along the stream (less than 10 feet) and to restrictive climatic conditions. Hence, the Crandall Creek area adjacent to the surface facilities is also not an alluvial valley floor. This conclusion is supported by the U.S. Soil Conservation Service (see Appendix 7-12).

7.25 Baseline Cumulative Impact Area Information

Sufficient information was provided by the Applicant during the initial permitting of the Crandall Canyon Mine for the Division to develop a Cumulative Hydrologic Impact Assessment (CHIA).

7.26 Modeling

No modeling has been conducted at this site, nor is any planned at this time.

7.27 Alternative Water Source Information

Genwal recognizes the fact that the Division of Wildlife Resources and the Division of Oil, Gas & Mining consider all seeps and springs to be important to wildlife. If, during the monitoring of the springs, it is proven that mining activities have reduced the flow of any seep or spring in the area by 50% or more, Genwal will notify the Division of Wildlife Resources, The Division of Oil, Gas and Mining and the U.S. Forest Service and begin working on an acceptable mitigation plan involving the use of guzzlers. The Utah Division of State Lands and Forestry will also be conferred with in formulating any mitigation plans that will affect the lands in the State Leases. These guzzlers will be designed in cooperation with the Division of Wildlife Resources, the Division of Oil, Gas and Mining and the U.S. Forest Service and placed in the area of the effected spring. No other sources of water, other than the springs located by the seep and spring survey, are known to exist in the mine plan area. Genwal owns shares in the Huntington-Cleveland Irrigation Company that can be transferred if required, to meet the demands of an alternate water supply. A copy of the water share certificate which would be used as an alternative water source is included in Appendix 7-14.

7.28 Probable Hydrologic Consequences Determination

The Probable Hydrologic Consequences (PHC) is included as a separate document in Appendix 7-15.

7.29 Cumulative Hydrologic Impact Assessment

The Division has prepared a Cumulative Hydrologic Impact Assessment (CHIA) for this operation in the initial permit. An updated, complete PHC is provided in Appendix 7-15 to aid in the determination as to whether a new CHIA is required for this renewal.

7.30 Operation Plan

7.31 General Requirements

This section describes the groundwater and surface water protection plan and water quality monitoring program implemented within the existing permit area and to be implemented for the refuse disposal site. The purpose of the groundwater and surface water protection plan is to minimize the potential for water pollution and changes in water quality and flow for surface and groundwater within and adjacent to disturbed areas. The purpose of the water quality monitoring program is to identify the potential impacts of coal mining operations on the hydrologic balance.

7.31.1 Hydrologic Balance Protection

Surface and Groundwater Protection Plan

The Applicant includes in this application a plan to protect the surface and groundwater in the area of the mine facilities, topsoil storage site and refuse disposal site. The plan will ensure protection of the ground water and surface water resources of the sites by handling earth and refuse materials in a manner that prevents or controls, using the best technology currently available, the discharge of pollutants to the hydrologic system. Additionally, the Applicant commits to handle acid- and toxic-forming materials, if encountered in the future, in a manner that will minimize acid- and toxic- forming discharge to surface or groundwater. The design details of the water protection plans are presented in Section 7.42 of this application.

7.31.2 Water Monitoring

Water monitoring data will be collected at the locations and frequencies described in the following plans for Groundwater and Surface Water Monitoring. Collection frequencies may vary based on accessibility of the sites. Water monitoring reports will be submitted to the Division on a quarterly basis, and a summary report will be submitted yearly with the Annual Report for the mine.

All test and measurement instruments are operated, maintained and calibrated in accordance with the manufacturers instructions. The results of all field measurements are recorded and initialed by the sampler.

When laboratory measurements are required, a specific set of sample bottles are pre-ordered from the laboratory. Bottles received from the laboratory are clean, pre-acidified and color-coded. Once the sample bottles are filled, they are individually labeled with water-proof, smudge-proof labels, placed in ice chests with ice packs and returned to the laboratory as soon as possible to insure proper holding times are met.

7.31.21 Groundwater Monitoring Plan

As noted in Section 7.24.1 only four springs were found during the June 1985 seep and spring survey within the area of potential subsidence with flow rates of one to two gallons per minute (SP-16, SP-17, SP-30, SP-36). By the time of the fall survey, all seeps and springs with the area of potential subsidence except SP-30 and SP-36 had dried up. SP-30 occurs as diffuse seepage from the Blackhawk Formation above the mine portals and is collected in a pipe to avoid problems at the portal face. Flow at SP-36 issues from a sandstone-shale contact within the Blackhawk Formation and showed evidence of use by elk and deer. All major springs (flows of at least five gallons per minute) found during the June 1985 survey were located outside of the area of potential subsidence at that time.

The Right-of-Way and State Leases have since been added to the permit area, and the area of potential subsidence has therefore expanded. Additional spring and seep surveys were conducted in 1987, 1989, 1990. The proposed groundwater monitoring program described below is based on the results of those surveys and is designed to evaluate impacts from the entire permit area, including the State Leases.

Groundwater monitoring for the Crandall Canyon Mine area will include collection of water quality and quantity data from eight springs as well as points of significant inflow to the underground workings.

SP-30 and SP-36 will be monitored to determine potential impacts in the immediate vicinity of the mine.

SP-58 will be monitored as an indicator of long-term changes in groundwater issuing from the Blackhawk Formation in a area that will not be affected by mining operations. The magnitude of these changes will be useful when interpreting changes at SP-30 and SP-36.

SP2-24, SP2-9 and SP-47a will be monitored since a water right has been filed on the springs by the U.S. Forest Service. Springs SP-19 and SP-22 will be monitored as indications of the water supply in the upper reaches of Blind Canyon.

Samples will be collected quarterly from each of the monitored springs until the surface areas are reclaimed. Following reclamation the samples will be collected semiannually until the surety bond is released. At least one of these samples will be collected during the low-flow period (normally the fourth quarter). These samples will be collected as close as possible to the point of issuance of the springs. Samples will be analyzed according to the list of parameters in Table 7-4. Samples collected during the low-flow period of the year (fourth quarter) will be analyzed according to the list of parameters contained in Table 7-5 (as requested in guidelines from DOGM) in the years 1990, 1995, 2000, and at 5-year intervals thereafter until the surety bond is released.

Because SP-30 is collected in a pipe to bypass the portal area, its discharge point is accessible year-round. Hence, this spring will be monitored and analyzed according to the Table 7-4 at the point of pipe discharge quarterly until the surface areas have been reclaimed. Following reclamation, SP-30 will be monitored and sampled according to Table 7-4 semiannually until the surety bond is released. The sample collected during the low-flow period (normally the fourth quarter) will be analyzed according to Table 7-5 in the years 1990, 1995, 2000, and at 5-year intervals thereafter until the surety bond is released.

All samples will be preserved as soon as practicable after collection. Samples will be collected and analyzed according to the methodology in the current edition of "Standard Methods for the Examination of Water and Wastewater" or the methodology in 40 CFR Parts 136 and 434.

On a quarterly basis an inventory will be conducted of the active portion of the mine to identify the location and geologic occurrence of mine inflows that exceed three gallons per minute. In consultation with DOGM, certain of these inflows (if they occur) will be selected for continued monitoring. Currently, only one such inflow exists, flowing from the roof of the mine from an exploratory hole (DH-1) that was vertically drilled from within the permit area at the location shown on Plate 3-2 (listed as "DRILL HOLE"). This hole is capped and is allowed to flow only when needed to collect water-quality data.

After selection of the inflow points to be monitored, data will be collected on a quarterly basis and analyzed according to Table 7-4. Samples collected during the low-flow period (normally the fourth quarter) will be analyzed according to Table 7-5 in the years 1990, 1995, 2000, and at 5-year intervals thereafter. Monitoring and sampling of the selected mine inflow points will continue according to this schedule in safely accessible portions of the mine.

Water rights apparently have been filed for two additional springs in the area surrounding the lease areas (93-1407 and 93-1408 on Plate 7-14). As noted in Section 7.24.1 the source at 93-1407 was not discovered until the fall of 1990. Until this time it was surmised to exist as only a seep (similar to 93-1408 (SP-47). Since its discovery Genwal has committed to monitoring and sampling SP-1407 (SP-47a) in the groundwater monitoring plan submitted with the Right-of-Way application. Source 93-1408 existed as a seep in June but was dry in October, 1985. Hence, it was decided not to monitor 93-1408 on a long-term basis since it does not flow at a sufficient rate to permit sample collection. SP-47 was observed to be dry in October, 1989 and in June of 1990.

Genwal installed monitoring wells near the mine portal (MW-1), and in the East Mains near their junction with the North Mains (MW-2) (Plate 7-13). These locations were chosen in areas where access will be maintained as long as possible.

Each underground monitoring well was drilled using air-rotary techniques. MW-1 was drilled to a total depth of 375 feet (Figure

Table 7-4. Abbreviated groundwater analysis list.

Field Measurements:
Water level or flow
pH
Specific conductance (umhos/cm)
Temperature (°C)
Laboratory Measurements:
Total dissolved solids
Total hardness (as $CaCO_3$)
Bicarbonate (as HCO_3)
Carbonate (as CO_3)
Calcium (as Ca)
Chloride (as Cl)
Dissolved iron (as Fe)
Magnesium (as Mg)
Manganese (as Mn)
Potassium (as K)
Sodium (as Na)
Sulfate (as SO_4)

Table 7-5. Extended groundwater analysis list.

Field Measurements:

Water level or flow
pH
Specific conductance (umhos/cm)
Temperature (°C)

Laboratory Measurements:

Total dissolved solids
Total hardness (as $CaCO_3$)
Aluminum (as Al)
Arsenic (as As)
Barium (as Ba)

Bicarbonate (as HCO_3)
Baron (as B)
Carbonate (as CO_3)
Cadmium (as Cd)
Calcium (as Ca)

Chloride (as Cl)
Chromium (as Cr)
Cooper (as (Cu)
Fluoride (as F)
Dissolved iron (as F)

Lead (as Pb)
Magnesium (as Mg)
Manganese (as Mn)
Mercury (as Hg)
Molybdenum (as Mo)

Nickel (as Ni)
Nitrogen-Ammonia (as NH_3)
Nitrite (as NO_2)
Nitrate (as NO_3)
Potassium (as K)

Phosphate (as PO_4)
Selenium (as Se)
Sodium (as Na)
Sulfate (as SO_4)
Sulfide (as S)
Zinc (as Zn)

7-1). As 6 5/8-inch diameter steel casing was cemented within a 10-inch diameter hole to a depth of 100 feet. A 6-inch diameter open hole completion exists from 100 to 375 feet. MW-2 was drilled to a total depth of 134 feet. Four-inch casing was set to 5 feet. A 3-inch open hole completion exists from 5 to 134 feet. Drilling of a larger diameter hole at greater depth was precluded by the inability of a larger drill rig to mobilize underground.

After drilling, each hole was surged with air to remove fines that had accumulated in the holes. Surging continued until the water discharging from the holes was visibly clear. A cap was placed over the surface casing to allow closure of each well when not in use.

Construction and initial sampling of the underground monitoring wells was completed in June, 1989. Lithologic/completion logs of the wells have been submitted to DOGM along with the results of analyses of the first samples collected from the wells. An interpretation of the hydrogeology of the Star Point aquifer beneath the mine appears in Section 7.24.1.

Water-level measurements and water-quality samples will be collected from the monitoring wells on a quarterly basis following completion. During the first two years following completion of the in-mine wells and in the years 1990, 1995, 2000 and in 5-year intervals thereafter, during the operational period of the mine, water-quality samples collected from all wells will be analyzed according to the list provided in Table 7-4. Monitoring will continue according to this schedule in accessible wells until two years after the completion of surface reclamation activities.

Each monitoring well will be pumped prior to sampling to purge it of stagnant water standing in the hole. In the case of M-1, purging will be accomplished using a submersible pump. A bladder pump will be used for purging MW-2.

In each case, purging will continue until at least 3 times the volume of water standing in the well has been pumped. Samples will be collected directly from the discharge line of the pump. Samples will be preserved and stored in accordance with U.S. Environmental Protection Agency guidelines.

Groundwater monitoring data collected from the area will be submitted to DOGM on a quarterly basis. On an annual basis, a report will be submitted to DOGM summarizing all data collected during the year and containing an analysis of the mine water balance, accounting for mine inflows, outflows, consumptive uses, and sump storage.

After the completion of mining activities and during the post-mining/reclamation period, water-level and quality samples will be collected annually from the designated springs and MW-1 until the termination of bonding. In-mine wells will be inaccessible following reclamation. Samples will be collected during the latter portion of the summer to represent low-flow conditions. Samples thus collected will be analyzed for the parameters listed in Table 7-4. A report will be submitted to DOGM on an annual basis summarizing the results and assessing mining impacts and system recovery since mining ceased.

7.31.22 Surface Water Monitoring Plan

Two 36-inch Parshall flumes were installed in July 1985 on Crandall Creek (one upstream from the surface facilities and one downstream: see Plate 7-7). A 12-inch Parshall flume has been installed in Blind Canyon to monitor possible effects of mining in State Lease ML-21569. These flumes are equipped with Stevens Type-F water-level recorders to allow the collection of continuous flow data. Charts will be changed and the flumes inspected on a monthly basis.

Water quality samples will be collected from the flume locations quarterly, and analyzed according to the list contained in Table 7-8. In the years 1990, 1995, 2000 and every fifth year thereafter the samples collected during the low-flow period (normally fourth quarter) will be analyzed according to Table 7-9. All samples will be analyzed for total and dissolved constituents according to the indicated lists. Sampling and analysis will be conducted quarterly until the surface areas are reclaimed, at which time sampling will be conducted semiannually until the surety bond is released. For perennial streams, those samples will be collected during high-flow (normally second quarter) and low-flow (normally fourth quarter) periods. Discharges from the sedimentation pond will be analyzed in accordance with the NPDES permit for the facility.

Stream flow observations made during drilling operations as well as seep and spring surveys suggest that large portions of the south fork of Horse Creek, Blind Creek, and both the north and south forks of Crandall Creek have only ephemeral and intermittent flows within State Leases ML-21568 and ML-21569. Plates 5-2A and 5-2B show the points of transition between perennial and intermittent flow.

Stream channel monitoring stations have been established along both the north and south forks of Crandall Creek, Blind Creek, and the south branch of Horse Creek to determine what stream reaches exhibit perennial flow. Stream flow and water temperature were measured twice monthly from May through July, and monthly during the remainder of 1991 when the area was accessible. Stream monitoring results are found in Table 7-6a. Stream monitoring was again done on September 28, 1992. These results are also listed in Table 7-6A. Stream monitoring ceased at the end of 1992 and a determination of what stream reaches exhibit perennial flow has yet to be made.

In anticipation of obtaining additional coal lease areas through Lease By Application No. 9, a flume was installed in Indian Creek (in Joes Valley). The location of this flume is depicted on Plate 7-7.

When flumes or other monitoring devices are no longer required, they will be removed and the affected areas will be restored.

No retreat mining will be conducted within the stream channel buffer zones of both the south and north forks of Crandall Creek, Blind Creek, and the south fork of Horse Creek until Genwal has shown what reaches of these streams are perennial, and that these reaches will not be adversely affected by mining activity.

Surface-water monitoring data will be submitted to DOGM on a quarterly basis. At the end of each calendar year, an annual summary will be submitted. This annual summary will analyze and describe variations in flows and quality during the year and will include tables, graphs, hydrographs, etc. as appropriate.

Due to the close proximity of the sedimentation pond to Crandall Creek, the piezometer installed in the dam (see Plate 7-4) will be monitored on a quarterly basis to reduce the likelihood of a potential dam failure.

Water-level measurements will be collected from the piezometer immediately prior to and following full-scale clean out of the sedimentation pond. If the pre- and post-cleaning water levels vary by less than 0.5 foot, monitoring following clean out will occur on a weekly basis for a period of one month. If significant changes are not noted during this one-month period (as determined in consultation with DOGM), the monitoring frequency will return to a quarterly interval. If significant water-level changes are noted during the post-clean out weekly monitoring period or if there is other evidence to indicate that the embankment is rapidly saturating, Genwal will notify DOGM within a 14-day period of the water-level changes and will mutually agree upon additional monitoring requirements.

The slope-stability analysis presented in Appendix 7-6 assumed that the water level at the location of the piezometer (Section B-B') was at an elevation of 7764 feet (20 feet below the surface of the embankment at the piezometer). Under these conditions, the dam was shown to be stable. If the water level in the piezometer rises above this elevation, water will be immediately withdrawn from the pond. If available data indicate that the water in the pond meets the effluent limitations contained in R614-301-751 and any applicable NPDES permits, this water will be pumped directly to Crandall Creek. Any direct discharges will be monitored at the beginning and end of pumping from the pond. The pump inlet will be placed on a floating spring to avoid pulling excess sediment into the discharge table during pumping. Water will be pumped from below the water surface to avoid introduction of oil to the discharge water.

If the pond requires rapid dewatering and the quality of the water is such that it cannot be discharged directly to Crandall Creek, the water will be pumped into sumps contained in the underground workings. These sumps are constructed large enough to provide for storage of the surface water. Once the water in the underground sumps is of sufficient quality to meet the effluent limitations of any applicable NPDES permits, the water will be discharged to Crandall Creek. Genwal is currently reviewing their existing NPDES permit to determine if a new or revised permit will be required to discharge water from the sedimentation pond to the underground workings and thence to the creek.

During the post-operational period, surface-water data will be collected from the upper and lower stations shown in Plate 7-7 and the inflow to the sedimentation pond as indicated on Plate 5-16. Flow data will be collected continuously from the flumes at the upper and lower Crandall Creek stations and twice annually (during the high- and low-flow seasons) from the sedimentation pond inflow during the post-mining period. In addition, water-quality samples will be collected from each station during the high- and low-flow seasons following mining. These samples will be analyzed for the parameters listed in Table 7-8. Data thus collected will be submitted to DOGM on a quarterly basis.

The post-mining reports will contain not only the laboratory and field data but also an assessment of current impacts from mining on surface-water systems and the amount of recovery of the system since mining. Surface-water monitoring following mining will continue until the termination of the bonding period.

7.31.3 Acid- and Toxic- Forming Materials

As discussed in Section 5.28.30, waste rock is not produced during mining operations. When incidental quantities of rock are encountered, the rock is left in the mine and will not be removed at any time in the future; thus, no negative effects are expected from the acid-forming potential of strata which overlie and underlie the Hiawatha seam. However, to further characterize the acid-forming potential of strata immediately above and below the Hiawatha seam, the applicant will collect additional roof- and floor-rock samples from three equally spaced locations within the current mine workings (including the state lease and right-of-way areas). Analytical results from these three sets of samples will be used to evaluate the need for additional sampling to adequately characterize the acid-forming potential of the strata.

The presence of acid- or toxic- forming materials will be determined by testing as described in the Soils Section, Chapter 2. If such material is identified, it will be stored in an enclosed area (i.e. dumpster) or within a containment (bermed) area until such time as it can be disposed of or buried. Any such material buried on site will be placed beneath a minimum of 4' of suitable material in accordance with requirements of R645-301-553.300 as described in Chapter 5, Section 5.53.3.

7.31.4 Transfer of Wells

Before final release of bond, exploratory or monitoring wells will be sealed in a safe and environmentally sound manner in accordance with Sections 7.38 and 7.65.

7.31.5 Discharges

The Applicant will not discharge into the underground mine, unless specifically approved by the Division and/or meets the approval of MSHA. Discharges will be limited to the following:

1. Water
2. Coal processing waste
3. Fly ash from a coal-fired facility
4. Sludge from an acid-mine-drainage treatment facility
5. Flue-gas desulfurization sludge
6. Inert materials used for stabilizing underground mines
7. Underground development waste.

7.31.5.1 Gravity Discharges

The angle at which the coal bed is inclined from the horizontal (dip) prevents any gravity discharge of water from the surface entries.

7.31.6 Stream Buffer Zones

The entire permit area is drained by ephemeral "streams"; however, portions of the road and sediment pond outslopes lie within 100 of Crandall Creek, a perennial stream. The stream is protected along these areas by the use of revegetation, silt fences and/or straw bales, and the placement of buffer zone signs. The buffer zone signs designate the area beyond which no disturbance shall take place.

7.31.7 Cross Sections and Maps

Cross sections and maps, as required for R645-301-731.700, are presented within this application.

Table 7-8. Abbreviated surface water analysis list.

Field Measurements:
Water level or flow
pH
Specific conductance (umhos/cm)
Temperature (°C)
Dissolved oxygen (ppm)
Laboratory Measurements:
Total dissolved solids
Total suspended solids
Total settleable solids
Total hardness (as $CaCO_3$)
Acidity as ($CaCO^3$)
Bicarbonate (as HCO_3)
Carbonate (as CO_3)
Calcium (as Ca)
Chloride (as Cl)
Dissolved iron (as Fe)
Total iron as (Fe)
Magnesium (as Mg)
Manganese (as Mn)
Potassium (as K)
Sodium (as Na)
Sulfate (as SO_4)
Oil and Grease
Cation - Anion balance

Table 7-9. Extended surface water analysis list.

Field Measurements:
Flow
pH
Specific conductance (umhos/cm)
Temperature (°C)
Dissolved oxygen (ppm)

Laboratory Measurements:
Total dissolved solids
Total suspended solids
Total settleable solids
Total hardness (as $CaCO_3$)
Acidity as ($CaCO^3$)
Aluminum (as Al)
Arsenic (as As)
Barium (as Ba)
Bicarbonate (as HCO_3)
Boron (as B)
Carbonate (as CO_3)

Cadmium (as Cd)
Calcium (as Ca)
Chloride (as Cl)
Chromium (as Cr)
Copper (as Cu)
Fluoride (as F)
Dissolved iron (as F)
Total iron as (Fe)
Lead (as Pb)
Magnesium (as Mg)
Manganese (as Mn)

Mercury (as Hg)
Molybdenum (as Mo)
Nickel (as Ni)
Nitrogen-Ammonia (as NH_3)
Nitrite (as NO_2)
Nitrate (as NO_3)
Potassium (as K)
Phosphate (as PO_4)
Selenium (as Se)
Sodium (as Na)

Sulfate (as SO_4)
Sulfide (as S)
Zinc (as Zn)
Oil and Grease
Cation - Anion balance

7.31.8 Water Rights and Replacement

In the event that the monitoring program identifies an impact to the water source in the permit and adjacent areas, the replacement of water rights will be addressed as described in Section 7.27 of this application.

7.32 Sediment Control Measures

The sediment control measures for the Crandall Canyon Mine operations are discussed in Section 7.42 of this application. This includes design, operation and maintenance of applicable siltation structures, sedimentation pond, diversions, and road drainage, as required.

7.33 Impoundments

There are no permanent impoundments associated with the Applicant's operations. Temporary impoundments of water collected for runoff control will occur in the sediment ponds and containment berms. The design of these structures is presented in Section 7.42 and 7.43 of this application.

7.34 Discharge Structures

Discharge from the sediment ponds will be conveyed by a CMP culvert and an open channel acting as the principal and emergency spillways. The outlets of these spillways will be protected by riprap. This design will comply with the requirements of R645-301-744.

7.35 Disposal of Excess Spoil

No significant excess spoil will be developed by the underground mine. The only anticipated spoil will be from materials collected in the sediment ponds. This limited volume of material will be removed from the ponds and transported to an approved refuse disposal site. In the event spoil is generated during mining operations, this too will be transported to an approved refuse disposal site.

7.36 Coal Mine Waste

Any refuse will be disposed of in accordance with the designs presented in Chapter 5 and Section 7.46 of this application.

7.37 Noncoal Mine Waste

Noncoal mine waste will be stored and final disposal of noncoal waste will comply with R645-301-747.

7.38 Temporary Casing and Sealing of Wells

Each well which has been identified in the approved permit application to be used to monitor ground water conditions will comply with R645-301-748 and be temporarily sealed before use. Drilling and Sealing of such wells will be done according to the procedure described in Chapter 6, Section 6.41.

7.40 Design Criteria and Plans

7.41 General Requirements

The runoff control plans for the Crandall Canyon Mine facilities includes the diversion of the undisturbed runoff from areas contributing to the facilities, the collection of all runoff from disturbed areas associated with the sites and the containment and treatment of this disturbed runoff through the use of sediment ponds, strawbales, silt fence, riprap, mulches and revegetation. Plans for these activities are presented and discussed in the following sections.

7.42 Sediment Control Measures

7.42.10 General Requirements

Appropriate sediment control measures will be designed, constructed and maintained using the best technology currently available to:

1. Prevent, to the extent possible, additional contributions of sediment to stream flow or to runoff outside the permit area.

2. Meet the effluent limitations under R645-301-751.

3. Minimize erosion to the extent possible.

Sediment control measures include practices carried out within and adjacent to the disturbed area. The sedimentation storage capacity of practices in and downstream from the disturbed areas will reflect the degree to which successful mining and reclamation techniques are applied to reduce erosion and control sediment. Sediment control measures consist of the utilization of proper mining and reclamation methods and sediment control practices, singly or in combination.

Sediment control methods include, but are not limited to:

1. Retaining sediment within disturbed areas;

2. Diverting runoff away from disturbed areas;

3. Diverting runoff using protected channels or pipes through disturbed areas so as not to cause additional erosion;
4. Using straw dikes, riprap, check dams, mulches, vegetative sediment filters, dugout ponds and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment;
5. Treating with chemicals/paving;
6. For the purposes of UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES, treating mine drainage in underground sumps.

7.42.20 Siltation Structures

7.42.21 General Requirements

Additional contributions of suspended solids and sediment to stream flow or runoff outside the permit area will be prevented to the extent possible using the best technology currently available.

Small Area Exemptions (S.A.E. Areas)

Small-area exemptions are requested for the seven areas shown on Plate 7-16 and Plate 2-3. SAE-1 (with a surface area of 0.02 acre) is the outslope of the access road to the administration pad of the western end of the surface facilities as well as to proposed U.S. Forest Service facilities to be located upstream from the mine facilities. Runoff from this area cannot feasibly drain to the sedimentation pond without excessive disturbances adjacent to Crandall Creek.

Runoff will occur from SAE-1 as sheet flow toward Crandall Creek. The area was reclaimed as outlined in Section 515.300 for contemporaneous reclamation. Reclamation commenced during the autumn 1986 immediately following completion of construction associated with the area. Maintenance of the revegetation effort will occur as outlined in Section 525.300. Immediately following revegetation, a straw-bale dike was installed along the entire toe of SAE-1 to control sediment yields from the area prior to effective establishment of the vegetation. This has since been replaced with a silt fence in areas where the width of the revegetated section is less than 5 feet.

Calculations required to determine the effectiveness of the vegetation in controlling sediment yield from SAE-1 are contained in Appendix 7-9. According to these calculations, with the lower five feet of the reclaimed area acting as a grass filter, the peak suspended sediment concentration yielded by SAE-1 during the 10-year, 24-hour storm is 12 milligrams per liter. This value is less than the fluent concentration for total suspended solids required by regulation.

SAE-2 (consisting of 0.34 acre) exists at the northwest corner of the site. This area was initially constructed as a substation pad and associated access road. Because the substation has not been installed and may not be installed in the future, SAE-2 will be reclaimed. Of the total area, 0.15 acre received final reclamation treatment and 0.19 acre received contemporaneous reclamation treatment (see Chapter 5, Plate 7-16 and Plate 7-5C). An additional area of 0.90 acre of undisturbed area drains onto SAE-2 from above.

Site drainage could be constructed to cause this area to drain to the sedimentation pond. However, enlargement of the pond to accept runoff from this area would be feasible only if a culvert was installed in Crandall Creek. The resulting damage to Crandall Creek (i.e., removal of riparian vegetation, alteration of the channel cross section, etc.) for the sole purpose of sediment control is not considered justifiable.

SAE-2 was reclaimed (contemporaneous and final) as outlined in Section 525.300. A sediment trap was installed at the downstream end of this area to control sediment yield. This trap utilizes the maximum space available and has a surface area of 150 square feet (10 feet by 15 feet). A 12-inch CMP culvert was installed to act as a spillway. This culvert discharge into UD-1. Details of the design of the sediment trap are contained in Appendix 7-9.

The effectiveness of the sediment trap was modeled using SEDIMOT II. Results of these analyses are contained in Appendix 7-9. According to this information, the peak effluent concentration of suspended sediment from the trap will be 2898 milligrams per liter. Although this concentration is greater than the standard contained in the R645 rules, it is significantly less than the influent suspended sediment concentration from the undisturbed area that drains to the trap (17,320 milligrams per liter). Thus the net effect is to decrease suspended sediment concentrations from the area below that which would naturally occur.

As an option for further reducing effluent sediment concentrations, the possibility of adding silt fences to the sediment trap was examined. Adding silt fences to act as baffles within the trap (thus increasing the flow path and decreasing the dead space in the trap) did not significantly reduce the peak effluent concentration. Adding silt-fence material to the inlet of the outflow culvert would increase detention time in the trap but would significantly reduce the hydraulic effectiveness of the spillway, thus increasing the potential for overtopping of the trap and subsequent downstream erosion. Thus, the sediment trap as designed was considered to be the best option for control of SAE-2.

SAE-3 consists of a small area (0.32 acre) on the south side of the U.S. Forest Service access road that has served in the past as the materials storage/office pad. The northern portion of this area was reclaimed using final reclamation techniques outlined in Section 3.5 (see Plate 7-5C). A berm of boulders was placed between SAE-3 and the road to prevent access to the reclaimed area. A straw-bale dike (Figure 7-11) was installed along the southern portion of the reclaimed area to serve as a sediment-control device prior to effective revegetation.

The southern portion of SAE-3 consists of boulders piled against the outslope of the pad. These boulders were blasted from the site high wall during initial construction. Due to potential stability problems that might be created by removal and the difficulty of removing these boulders from the outslope, this slope will remain unreclaimed.

The effectiveness of the reclamation activities was modeled using SEDIMOT II. Results of these calculations are contained in Appendix 7-9. According to this appendix, the peak effluent suspended sediment concentration from SAE-3 during the 10-year, 24-hour storm is 2 milligrams per liter. This concentration is within the standards established by the R645 rules.

SAE-4 consists of a 0.14 acre area on the outslope (south side) of the U.S. Forest Service road between SAE-1 and SAE-3. Periodic grading and maintenance of the access road results in fresh soil occasionally being deposited on the outslope, limiting the potential for the outslopes to be contemporaneously reclaimed. Thus, because the area does not report to the sedimentation pond, alternate sediment control will be provided.

Sedimentation control in SAE-4 will be provided by installing a silt fence along the entire length of the toe of the road outslope. The silt fence will be installed in accordance with Figure 7-12. The silt fence will be periodically inspected and repaired as required to ensure that its integrity is maintained.

SAE-5, SAE-6, and SAE-7 consist of the topsoil stockpiles that are located on the south side of the access road east of the mine site in the areas indicated in Figure 7-12. Sae-6 and SAE-7 also include small gravel stockpiles used for maintenance of the access road. Disturbed areas associated with the topsoil/gravel small-area exemptions are 0.20 acre, 0.22 acre, and 0.62 acre for SAE-5, SAE-6, and SAE-7, respectively.

Sedimentation control for SAE-5, SAE-6, and SAE-7 will be provided by installing straw-bale dikes around the perimeter of each disturbed area. These dikes will be installed in accordance with Figure 7-11. The dikes will be periodically inspected and repaired as required to ensure that their integrity is maintained.

SAE-8 consists of the Forest Service parking area west of the mine surface facilities (see Plate 7-16). This parking area was constructed by Genwal for the Forest Service during the latest surface expansion. Although it is not part of the surface facilities, it is a disturbed area within the permit boundaries. Sedimentation control will, therefore be provided. The disturbed area associated with SAE-8 is 0.17 acre.

Sedimentation control for SAE-8 will be provided by a silt fence installed in accordance with Figure 7-12 between the parking area and Crandall Creek. The silt fence will be periodically inspected and repaired as required to ensure that its integrity is maintained.

7.42.22 Sedimentation Pond

Design Criteria

Watershed boundaries used to determine runoff conditions at the site are shown on Plate 7-3. Data obtained from these watersheds were input to a computer code developed by Hawkins and Marshall (1979) to generate runoff hydrographs for the 10-year, 24 -hour storm required for designing various facilities. Inflow hydrographs to and outflow hydrographs from the sedimentation pond were developed for the 25-year, 24-hour storm using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980). Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

According to the U.S. Soil Conservation Service (1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations,

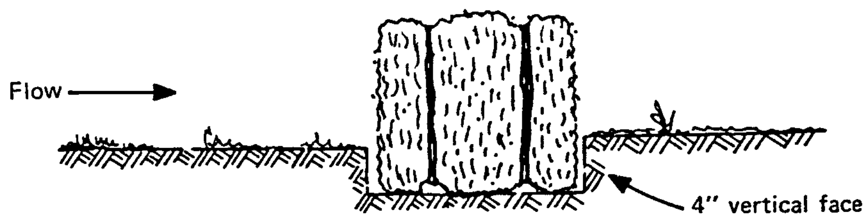
$$Q = \frac{(P-0.2S)^2}{P+0.8S} \qquad (7\text{-}1)$$

and

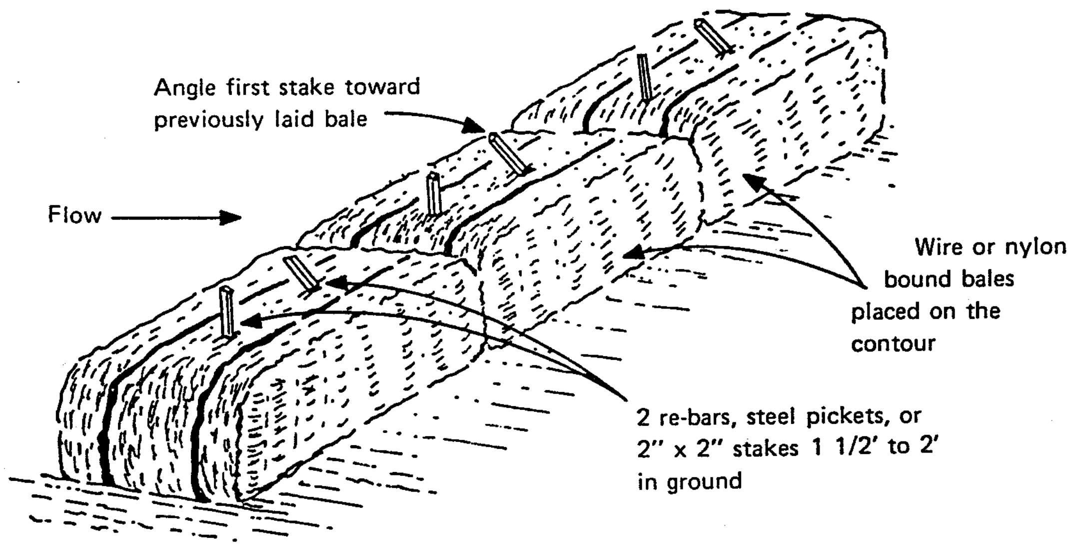
$$S = \frac{1000}{CN} - 10 \qquad (7\text{-}2)$$

where Q = direct runoff volume (inches)
S = watershed storage factor (inches)
P = rainfall depth (inches)
CN = runoff curve number (dimensionless)

It should be noted that (a) Equation (7-1) is valid only for P>=0.25 (otherwise Q=O). (b) Equation (7-2), as stated, is in inches, with the values of 1000 and 10 carrying the dimensions of inches, although metric conversions are possible, and (c) CN is only a convenient transformation of S to establish a scale of 0 to



Embedding detail



Anchoring detail

Figure 7-11. Typical straw-bale dike.

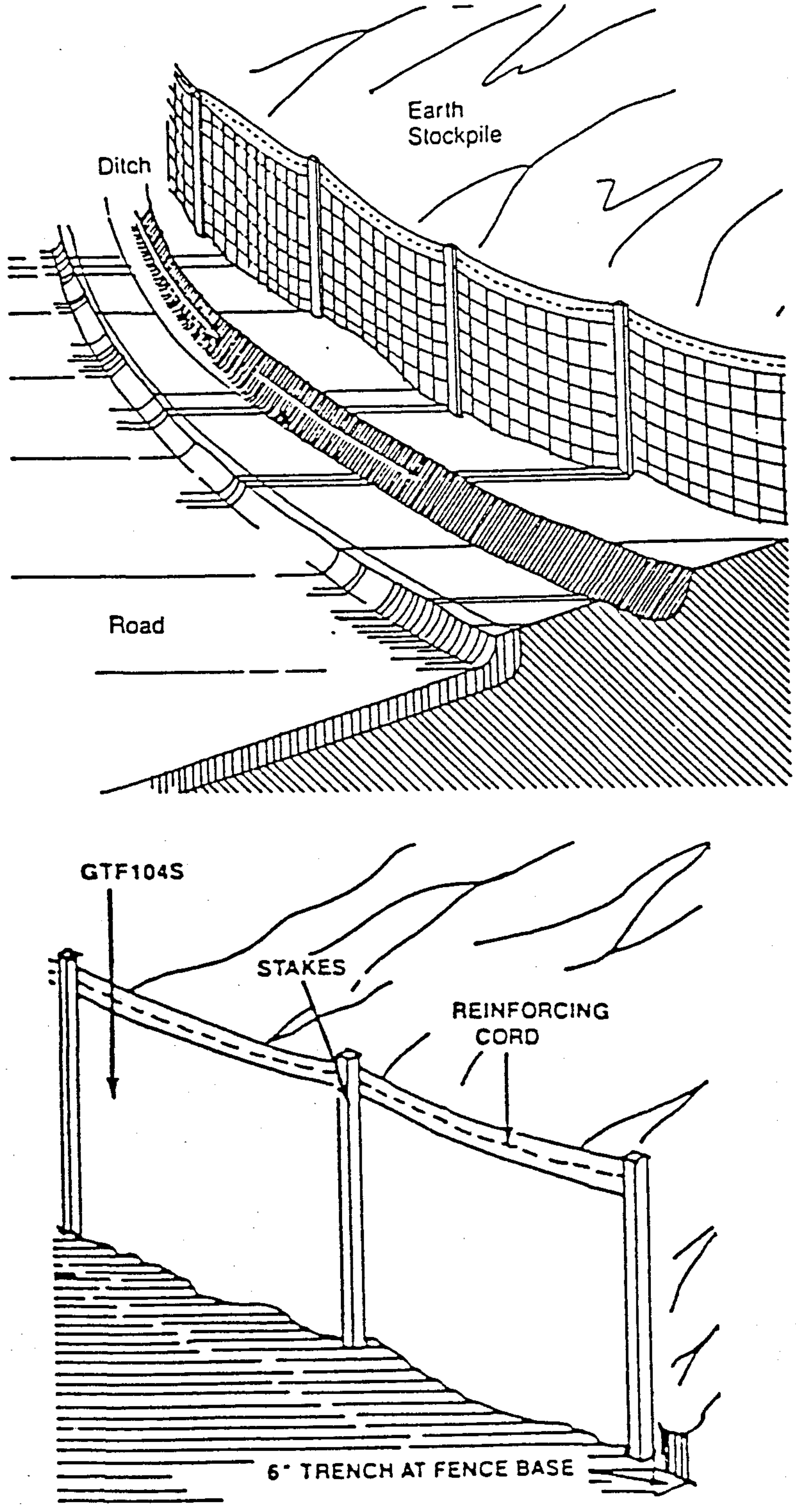


Figure 7-12.. Typical silt fence installation.

100 and has no intrinsic meaning.

The average curve number for undisturbed areas was obtained from the curves presented in Figure 7-3 using measured cover densities as reported in Chapter 3 of the Permit Application Package for the northern half of lease area SL 062648 (formerly referred to as Tract 2). A curve number of 69 was thus obtained for the undisturbed areas, assuming a hydrologic soil group of C.

The curve number for disturbed and reclaimed areas was chosen from professional judgement and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 90 was used for the pad and road areas. For reclaimed areas within the disturbed area, a curve number of 75 was assumed.

The translation of the runoff depth to an outflow hydrograph is accomplished in the codes using the triangular unit hydrograph of the U.S. Soil Conservation Service (1972). This unit hydrograph is shown in Figure 7-4 along with a typical curvilinear hydrograph. It is characterized by its time to peak (T_p), recession time (T_r), time of the base (T^b) and the relations between these parameters (i.e., T_r=1.67T_p; T_b=2.67T_p). Thus, from the geometry of a triangle, the incremental runoff (Q) can be defined by the equation.

$$Q = \frac{(2.67T_p)(q_p)}{2} \qquad (7-33)$$

or

$$q_p = \underline{0.75 \quad Q} \qquad (7-4)$$

where q_p = peak flow rate (dimensioned according to Q and T) and other parameters have been previously defined.

When Q is expressed in inches and T_p in hours, q_p will be in inches per hour. The flow at any time $0<t<T_r$ may be determined by simple linear proportioning of the triangular unit hydrograph. The time to peak is related to the familiar expression time of concentration (T_c) by the equation.

$$T_c + t = 1.7T_p \qquad (7-5)$$

in which the factor 1.7 is an empirical finding cited by the U.S. Soil Conservation Service (1972).

The time of concentration may be estimated by several formulas. For this report, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972).

$$L = \frac{\ell^{0.8}\,(S+1)^{0.7}}{1900\ Y^{0.5}} \qquad (7\text{-}6)$$

and

$$T_c = 1.67L \qquad (7\text{-}7)$$

where L = watershed lag (hours)
ℓ = hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)
S = watershed storage factor defined in Equation (2)
Y = average watershed slope (percent)
T_c = time of concentration (hours)

Diversions were designed to convey runoff from an undisturbed area away from the disturbed site using the Manning and continuity equations:

$$V = \frac{1.486}{n} R^{0.67} S^{0.50} \qquad (7\text{-}8)$$

and

$$Q = AV \qquad (7\text{-}9)$$

where V = velocity (feet per second)
R = hydraulic radius (feet)
S = hydraulic slope (feet per foot)
n = roughness coefficient
Q = discharge (cubic feet per second)
A = flow area (square feet)

Values of the roughness coefficient required for the solution of Equation (7-8) were obtained by comparing local conditions with tabulated values provided by the U.S. Soil Conservation Service (1956). An empirical formula developed by Anderson et al. (1970) was used to determine the roughness coefficient for riprap linings.

Calculations with Equations (7-8) and (7-9) were performed using an interactive computer code entitled TRAP1 as obtained from the U.S. Office of Surface Mining and outlined by Weider et al. (1983). This code was used to determine flow conditions in the diversion channel at the design flow rate.

The sedimentation pond at the downstream edge of the site has been designed with a primary and emergency spillway. The primary spillway consists of a CMP riser and pipe through the embankment while the emergency spillway consists of a riprapped overflow at the corner of the embankment.

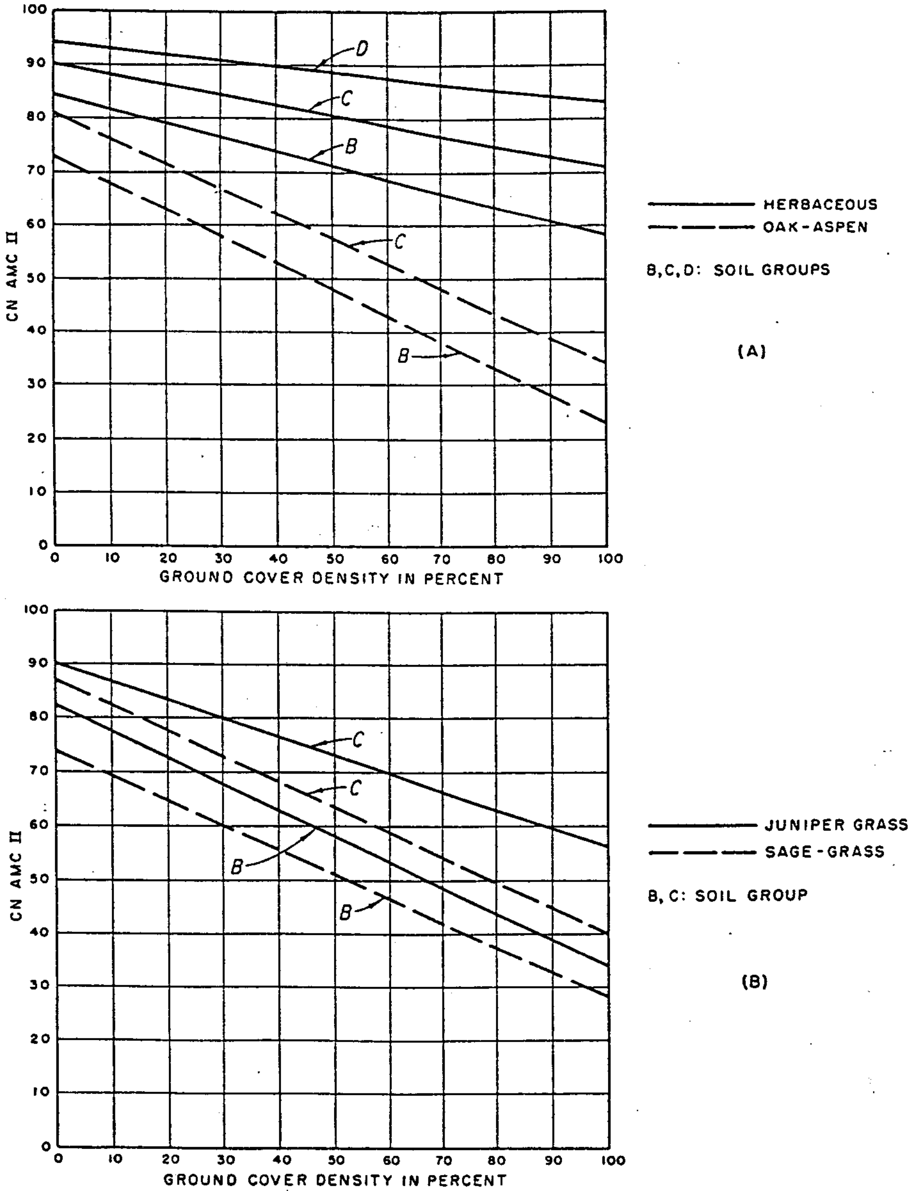


Figure 7-3. Runoff curve numbers for forest-range in the western U.S. (from U.S. Bureau of Reclamation, 1977).

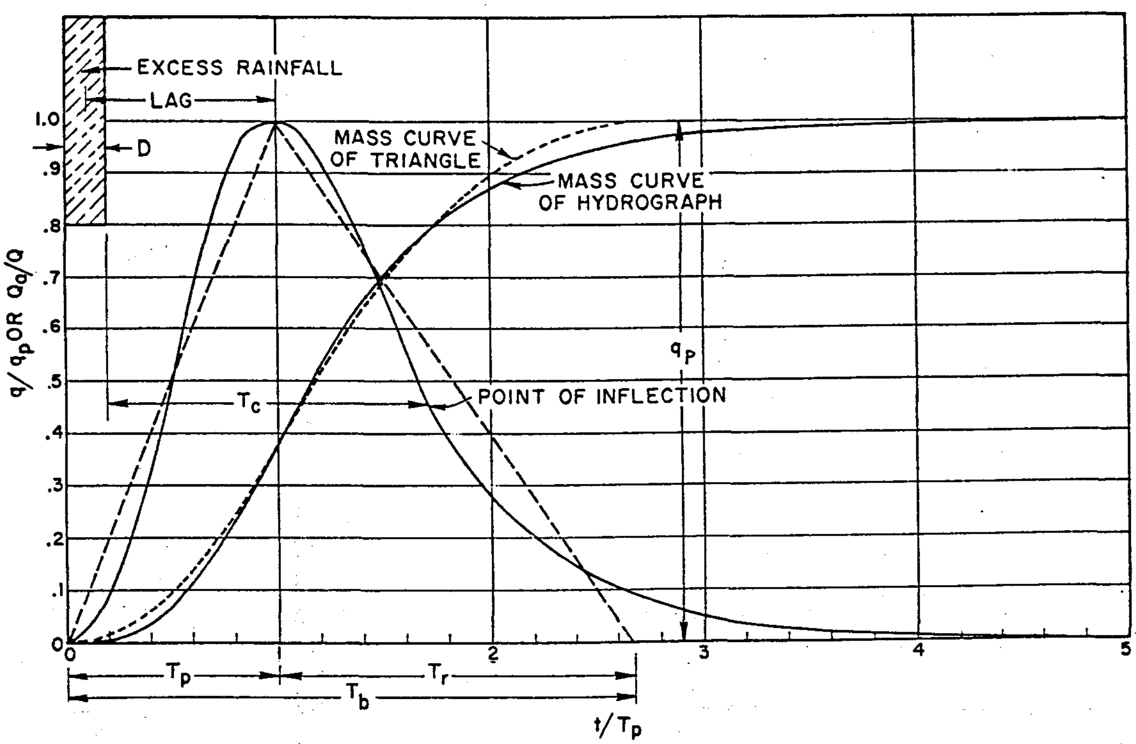


Figure 7-4. Curvilinear and triangular unit hydrographs (from U.S. Soil Conservation Service, 1972).

At low heads, the hydraulic capacity of the primary spillway behaves as a weir. According to Barfield et al. (1981), the equation for weir-controlled flow is

$$Q = CLH^{1.5} \qquad (7\text{-}10)$$

where Q = discharge (cubic feet per second)
C = weir coefficient
L = length of the weir (feet)
H = depth of water above the weir crest (feet)

A value of the weir coefficient equal to 3.1 was selected since the structure will act as a broad-crested weir (Barfield et al., 1981). The length of the weir is equal to the circumference of the CMP riser.

As the depth of water increases above the riser, the riser acts like an orifice. The equation for orifice flow is (Barfield et al., 1981)

$$Q = CA(2_gH)^{0.5} \qquad (7\text{-}11)$$

where C = orifice coefficient
A = cross-sectional area of the inlet (square feet)
g = gravitational constant (feet per second squared)

and other parameters have been previously defined. A value of 0.60 was selected for the orifice coefficient based on guidelines presented by Barfield et al. (1981).

Pipe flow occurs when the head increases sufficiently to cause the outlet of the discharge pipe leading from the riser to flow full. The discharge capacity of the culverts under pipe flow conditions was determined using the equation,

$$Q = A(2_g')^{0.5}/(1+K_e+K_b+K_cL)^{0.5} \qquad (7\text{-}12)$$

where H' = head on the pipe (feet)
K_e = entrance loss coefficient
K_b = bend loss coefficient
K_c = friction loss coefficient

and all other parameters have been previously defined. Values of 1.0. 0.5, and 0.062 were used for K_e, K_b, and K_c, respectively based on information provided by Barfield et al. (1981).

The discharge capacity of the emergency spillway was determined using a method developed by the U.S. Soil Conservation Service (1968) and expanded by Barfield et al. (1981) for broad-crested weirs. According to this methodology, the critical specific energy head (H_{ec}) is determined for selected values of the energy head of water in the pond (H_p) from Figure 7-5. The discharge capacity of the spillway is then calculated for the standard 100-foot wide rectangular section from the equation,

$$q_r = (0.544)(g^{0.5})(H_{cc}^{1.5}(100) \qquad (7\text{-}13)$$

where q_r = discharge for standard 100-foot rectangular section (cubic feet per second)

and all other parameters have been previously defined. The flow is then corrected for a trapezoidal section using the equation

$$q = ([1.5b + zH_{cc}]/150)(q_r) \qquad (7\text{-}14)$$

where q = corrected discharge (cubic feet per second)
b = bottom width of channel (feet)
z = channel side slope (run over rise - dimensionless)

The hydraulics of the spillway system was determined by assuming the pond was dewatered to the top of the sediment storage level prior to inflow from the 25-year, 24-hour storm.

Stability Analyses

Due to space restrictions, the sediment pond for the mine site was designed with upstream and downstream slopes both equal to 2h:1v. Since UMC 817.46(m) requires a combined slope of 5h:1v, a stability analysis was conducted to ensure that the pond embankment, as designed, would be stable.

The stability analysis was conducted using a microcomputer version of the program entitled STABL2 (Siegel, 1978). The modified Bishop method was used to calculate the factor of safety under both static and seismic conditions. Stability was modeled assuming both full and empty ponds, both with and without the designed clay liner functioning. Results of these analyses are presented in this section and Appendix 7-6.

Runoff- and Sediment-Control Facilities

Results of analyses to determine the required size and hydraulics of the sedimentation pond are included in Appendix 7-4. In sizing the pond, plans for future expansion of the surface facilities at the Crandall Canyon Mine were accounted for. Details of the sedimentation pond required for compliance with 30 CFR 77.216-1 and 30 CFR 77.216-2 are contained in Appendix 7-8.

Runoff to the sedimentation pond from the 10-year, 24-hour storm was determined to be 0.68 acre-foot (with 0.30 acre-foot originating on reclaimed and undisturbed areas and 0.38 acre-foot originating on disturbed and ponded areas). Required sediment storage for the pond was determined to be 0.31 acre-foot, including 0.27 acre-foot from disturbed areas and 0.03 acre-foot from undisturbed and reclaimed areas over a 3 year period. Hence, the pond was designed with a total storage volume of 0.98 acre-foot.

Plate 7-4 presents details of the sedimentation pond design. Cross sections referred to on the plate are found on Plate 7-6. Based on the topographic map of the pond, the stage-capacity curve provided in Figure 7-9 was developed. This stage-capacity curve has taken account of the clay liner and the gravel marker noted on Plate 7-4.

As noted in Figure 7-9, the pond provides sediment storage to an elevation of 7777.1 feet and total storage (sediment plus runoff) to an elevation of 7782.6 feet. Sediment will be cleaned out of the pond when it reaches an elevation of 7775.5 feet at the riser (the elevation corresponding to a volume of 60 percent of the required sediment storage volume). Two steel stakes are placed at the locations shown on Plate 7-4 to mark the sediment-clean-out elevation of 7775.5 feet.

Sediment removed from the pond will be initially stored in the location noted on Plate 5-3. Permanent disposal of the sediment will be in accordance with Section 535.

A previous riser in the sedimentation pond had an overflow elevation of 7779.4 feet and a decant elevation of 7777.1 feet. The decant system was installed according to Plate 7-6 (i.e., at the top of the sediment storage level). A gate valve was installed as noted to allow manual draining of the pond. A locked cap was placed over the access port to the gate valve to prevent unauthorized entry. The key to this valve is kept at the Genwal office in Huntington. Under no circumstances will water be discharged from the sedimentation pond to Crandall Creek prior to 24 hours from the end of the runoff event to the pond.

Prior to any discharges through the decant system on the sedimentation pond, a sample will be collected to determine total suspended solids, settleable solids, total dissolved solids, oil and grease, total iron, total manganese concentrations, and pH. The sample will be collected by opening the gate valve on the dewatering device, allowing water to flow from the pond through the primary spillway for a sufficient time to collect a sample of the water, and then immediately shutting the gate valve to prevent further dewatering. This sample will then be submitted to a laboratory for analyses of the indicated parameters.

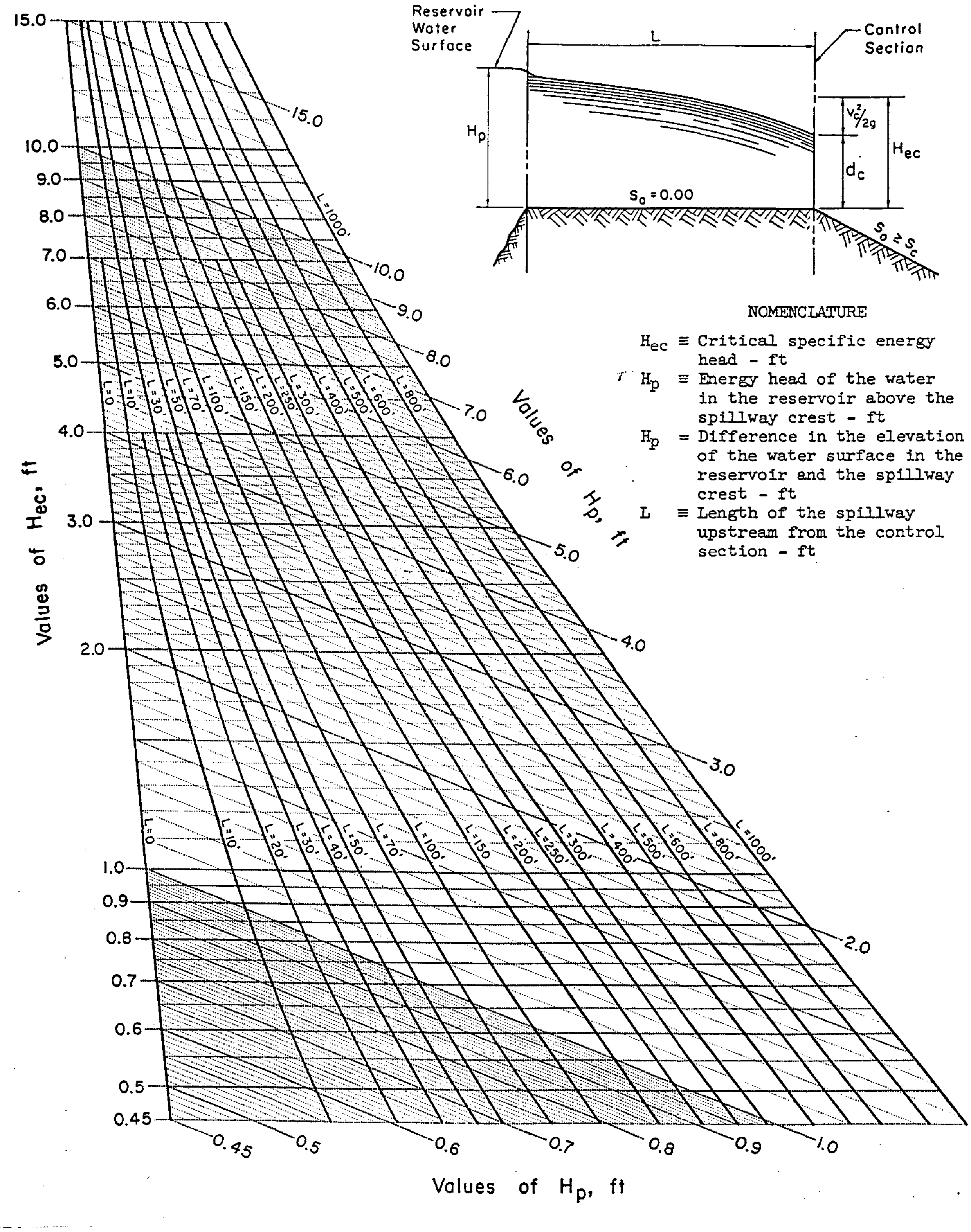


Figure 7-5. Head relationships for selected broad-crest weirs (from U.S. Soil Conservation Service, 1968)

After receipt of analytical results from the laboratory, if the pH and concentrations of total suspended solids, settleable solids, total dissolved solids, oil and grease, total iron, and total manganese are within the acceptable limits established by UMC 817.42 and the NPDES permit for the sedimentation pond, water will be discharged from the pond through the dewatering device. If the parameters of concern are not within the acceptable limits, no water will be discharged through the device.

The sedimentation pond will normally be dewatered directly to Crandall Creek. However, in the event of an emergency (e.g., runoff flowing into the pond when it is full but the quality of water in the pond is not sufficient to permit discharge to Crandall Creek), the pond will be pumped to the underground sump in the mine. No water will be discharged from the sump to the surface unless water in the sump is determined to meet the water-quality standards of the NPDES permit. This will be determined by opening the valve to the discharge line for a sufficient time to allow collection of a sample at the NPDES discharge point (i.e., the sedimentation pond outlet). This sample will likewise be analyzed for the parameters of concern. If the analytical results indicate that the water is of adequate quality, it will be discharged to the surface. If the water is not of adequate quality, it will not be discharged.

During discharge of water to Crandall Creek from either the sedimentation pond or the underground sump, samples of the water will be collected at the discharge point at the beginning, middle, and end of the discharge time. These samples will be sent to a laboratory following the discharge period for analyses of total suspended solids, settleable solids, total dissolved solids, total iron, total manganese, oil and grease, and pH. Analytical results will be submitted to the Division within 10 working days of receipt of these results from the laboratory.

The outflow point on the riser was raised 3.2 feet to an elevation of 7782.6 feet (the top of the total storage pool). This was accomplished with a section of 24-inch CMP clamped to the existing riser.

During the spring of 1989, leakage was noted through joints located in the lower portion of the sedimentation pond riser. This leakage has caused a slight but continual discharge from the sedimentation pond. To alleviate this leakage, the lower portion of the riser and the existing barrel will be plugged with cement. A new barrel will be installed through and down the face of the embankment. This riser will extend to Crandall Creek, discharging onto natural riprap that exists at the toe of the dam. Details of the proposed alteration to the sedimentation pond primary spillway are provided on Plates 7-6 and 7-6A.

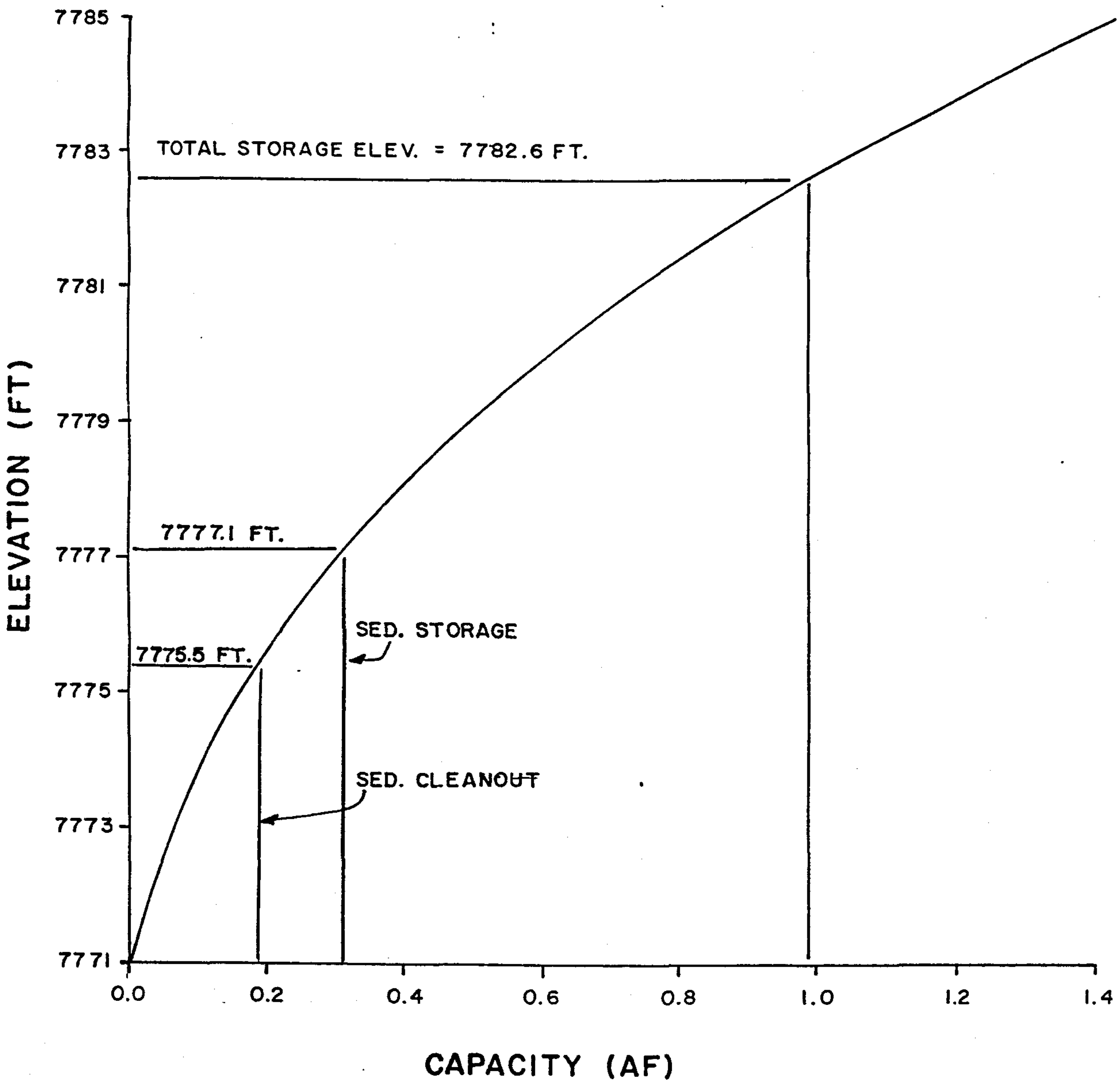


Figure 7-9. Stage-capacity curve for proposed sedimentation pond.

Results of inflow and outflow analyses from the 25-year, 24-hour storm using SEDIMOT II are presented in Appendix 7-4. It should be noted that the sedimentology option of SEDIMOT II was used during design only to permit routing of the hydrograph through the pond. However, since sediment contributions from the 25-year, 24-hour event are not of concern in design of the pond (only sediment yield from the 10-year, 24-hour and smaller storms is of regulatory concern), the sediment inputs to the model were suppressed. Thus, the output from the program indicates sediment concentrations of 0 milligrams per liter. Selected other outputs contained in Appendix 7-4 associated with sediment yield are, therefore, also meaningless.

It should also be noted that, although detention times shown on the output in Appendix 7-4 are relatively low (0.15 hour), these times have no regulatory meaning for a 25-year event (i.e., regulatory concerns address only the 10-year and smaller events). Again, the program was used primarily for its spillway-design capabilities and not for dealing with the specifics of sediment yield and detention times from the 25-year design event.

Utilizing the combined hydraulics of the primary and proposed emergency spillways, the peak outflow stage during the 25-year, 24-hour storm was calculated by SEDIMOT II as 6.0 feet above the sediment storage level. Thus, the outflow elevation during the design flow event was determined to be 7783.1 feet. The hydraulic effects of the primary spillway modification are discussed in Appendix 7-4. The effectiveness of energy dissipation of the discharge from the barrel of the spillway to the creek are also presented in Appendix 7-4.

The indicated overflow elevation during the design flow event (elevation 7783.1 feet) is lower than that of the proposed emergency spillway,indicating that water will not pass through the emergency spillway under design conditions. Nonetheless, an emergency spillway was installed at the request of the U.S. Forest Service to provide a factor of safety and a bypass for water during events larger than those for which the pond was designed. Conservatively, the emergency spillway crest was placed an elevation of 7784.0. As designed, this spillway has a bottom width of 4.0 feet and side slopes of 2h:1v.

As noted on Plate 7-4, the emergency spillway will discharge onto the boulder-covered slope adjacent to the sedimentation pond. Boulders that cover this slope were blasted from the cut above the pond during construction of the mine-access road. Due to the large size of the boulders, laboratory size-fraction analyses could not be conducted. However, the boulders are visually estimated to range in size up to at least 10 feet in diameter. It is further estimated that approximately 80 percent of the coarse rock on the slope is finer than 8 feet in diameter, 30 percent is finer than 5 feet in diameter, and 10 percent is finer than 3 feet in diameter.

The blasted rock has an approximate thickness of 15 to 20 feet at the top of the slope and 5 to 6 feet at the bottom of the slope. The soil that underlies the rock is a silty sand. Size-fraction analyses presented by Delta Geotechnical Consultants (1982) indicate that this soil is 70 percent sand and 30 percent silt and clay (the latter being minus 200 mesh).

The emergency spillway is lined with riprap and a filter blanket as noted in Appendix 7-4 to reduce erosion potential. Grading of the riprap, filter blanket, and embankment materials are shown in Figure 7-10. Design of this filter blanket is presented in Appendix 7-4. The spillway will discharge directly onto the boulder-covered slope. Due to the extreme thickness of the boulders and cobbles on the slope, additional erosion protection below the emergency-spillway outflow will not be required.

Since the emergency spillway will not be flowing during the design event, the regulations require only that the top of the settled embankment be 1.0 foot above the crest of the emergency spillway. This will result in an embankment crest elevation of 7785.0 feet. The crest of the existing embankment was at an elevation of 7783.0 feet, the design required the addition of 2.0 feet of settled embankment to the top of the existing embankment. No additional material will be added to account for settlement since (a) the embankment is being raised 0.4 feet more than required and (b) the existing embankment is assumed to have settled previously.

With a crest elevation of 7785.0 feet and a base elevation of 7771.0 feet at the upstream toe, the embankment has a height of 14.0 feet. The required top width of the embankment is 9.8 feet. An actual top width of 10.0 feet was constructed.

The existing pond was enlarged to meet the volume requirements of this plan by removing excess fill from the interior of the pond. In addition, the upper 12 feet of the exterior of the existing embankment was recontoured to a slope of 2h:1v. Prior to recontouring the exterior slope, all large rock fragments were removed.

All new fill required to raise the embankment was placed in 6-inch lifts. This new fill was compacted in place by repeated passes of a front-end loader or equivalent prior to placing the next lift. Compaction continued until the density of the material was at least 90 percent of Proctor density (as determined by sand-cone density tests in the fields).

Because of the location of the sedimentation pond on a hillside between the access road and Crandall Creek, insufficient space was available to permit construction of side slopes with a combined upstream and downstream slope of 5h:1v and still provide the required storage capacity. Hence, the pond has been designed with 2h:1v side slopes on both the upstream and downstream sides.

As included in the original design, the interior of the pond was lined with a 12-inch thick local, compacted clay to reduce seepage from the pond and, thereby, increase the stability of the embankment. The clay liner was placed in 6-inch lifts and compacted during placement by at least four passes of a frontend loader or equivalent. The initial layer was disk-harrowed into the bottom of the pond prior to completion.

After pond cleanout, the thickness of the clay liner will be sampled by means of a bucket auger at 8 locations. Three holes will be placed along the ingress/egress route and five additional holes will be randomly selected from the remaining pond area. If any of the holes penetrate less than 10 inches of clay, additional clay will be compacted into the deficient areas of the pond.

All new construction on the revised sedimentation pond was supervised by a Professional Engineer who is licensed in the State of Utah. An initial certification report was prepared and certified by the supervisory PE for submission to DOGM following completion of construction activities. Plate 7-4a shows as-built drawings of the pond and riser detail. Plate 7-6a shows as-built cross sections through the pond. Appendix 7-10 contains as-built calculations for the sedimentation pond and the initial certification report. The initial certification report previously submitted to DOGM included:

- Existing and required monitoring procedures and instrumentation

- The design depth and elevation of any impounded waters at the time of the report

- Existing storage capacity of the dam or embankment

- A discussion of any fires occurring in the construction material up to the date of certification

- A discussion of any other aspects of the dam or embankment affecting stability

Flow conditions in Crandall Creek adjacent to the sedimentation pond were examined to determine if flood flows may erode the downstream toe (see Appendix 7-5). As noted, the peak flow from the 100-year, 24-hour precipitation event will encroach 0.6 foot above the toe of the embankment. Thus, a riprap protective layer (with a median rock diameter of 12.5 inches) was placed along the lower 2.0 feet of the embankment as shown in Plate 7-4. Placement of this riprap will serve an incidental purpose of increasing the stability of the dam by placing additional weight on the downstream toe.

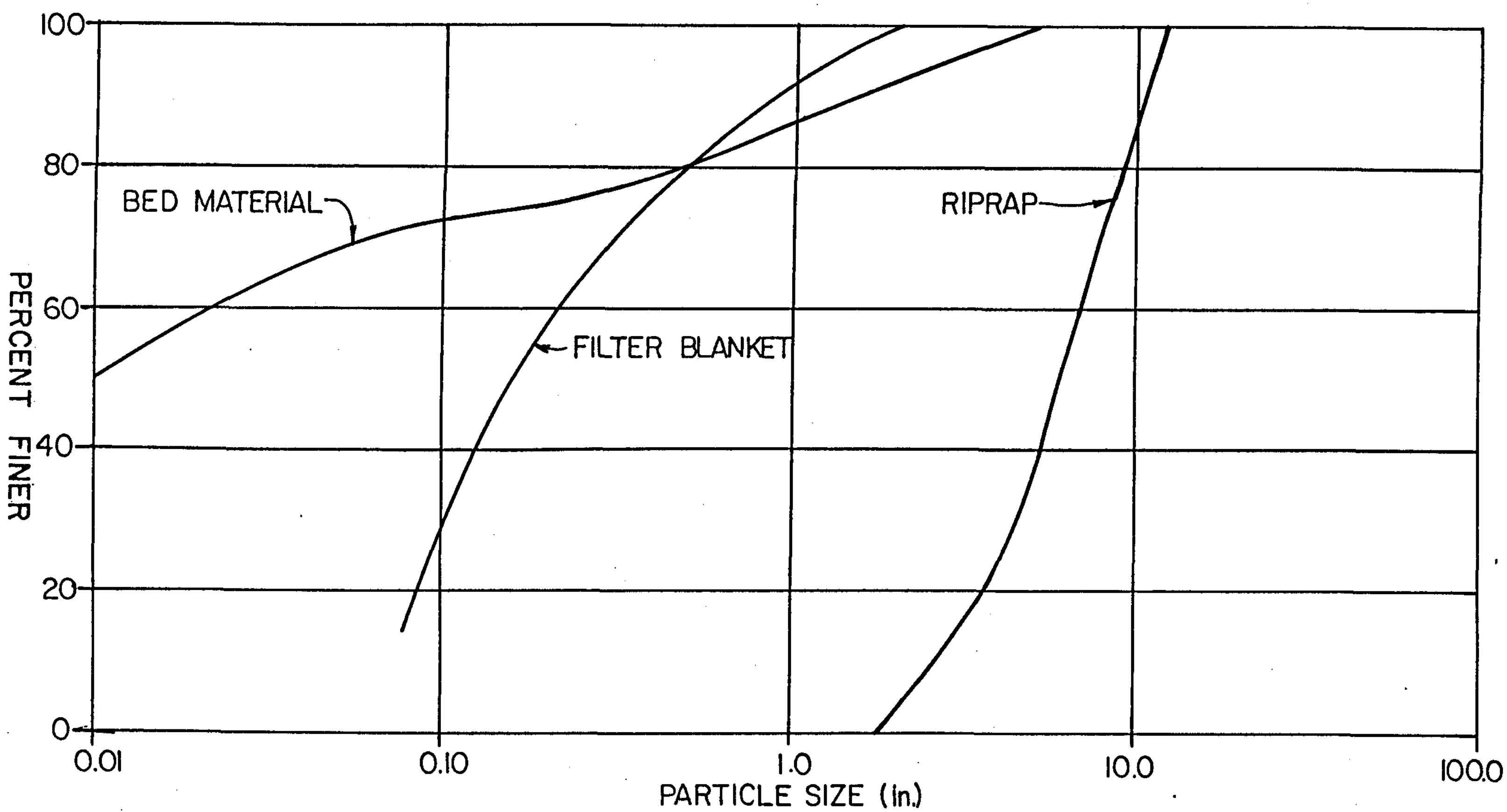


Figure 7-10. Gradation of embankment, filter, and riprap materials.

Although the presence of the sedimentation-pond dam adjacent to Crandall Creek may slightly alter flow conditions in the stream, the placement of erosion-protection features on the steep stream bank across from the pond is not considered justified for two reasons. First, placement of erosion-protection features on the bank across from the pond will likely cause more disturbance than it will prevent due to the steepness of the bank. Second, as noted in Appendix 7-5, the peak flow event for which the analysis was conducted has an estimated return period in excess of 10,000 years (due to the conservativeness of the storm distribution used in the analysis), indicating the remoteness of the possibility that the stream might overtop its banks and impinge on the dam.

As a result, while the pond is in operation, the stream bank across from the pond will be inspected each time the piezometer through the dam is monitored (see Section 7.2.6). If erosion occurs on the opposite stream bank due to the presence of the pond, a repair plan will be prepared and implemented in consultation with DOGM.

An analysis was conducted of the pond to determine the stability of the dam under selected conditions. Cross sections used for the analysis are shown on Plate 7-4, as are locations where Shelby-tube soil samples were collected for laboratory analyses to determine local soil properties. Results of the laboratory and stability analyses are presented in Appendix 7-6 and summarized in Table 7-7.

The required safety factors shown in Table 7-7 were developed in consultation with DOGM in a meeting on April 2, 1986 and Randy Hardin and Rick Summers of DOGM, Andrew C. King of Genwal and Richard B. White of EarthFax Engineering, Inc. A comparison of the required and actual safety factors indicates that the embankment as designed will be stable. It should be noted that these safety factors did not include the benefits due to installation of the riprap on the dam toe as discussed above.

Following construction of the sedimentation pond as designed herein, all disturbed areas associated with pond construction (with the exception of the interior of the pond) were revegetated with the temporary seed mixture. This mixture was developed in consultation with Lynn Kunzler of the Division and Walt Nowak of the U.S. Forest Service. This mixture provides rapid growth species, sod-forming species, and species that are compatible with other plants.

Seeding was done in the late fall of 1986, just prior to the first heavy snowfall of the year (Plummer et al., 1968). Seeding was accomplished by broadcasting with a cyclone seeder. Mulch was placed after seeding. The mulch, which consisted of two tons of straw or grass hay per acre of disturbed area, was spread over the area to be planted and crimped into the soil with a roto-tiller or shovel to aid in moisture retention (U.S. Soil Conservation Service, 1975).

Following seeding, the revegetated outslopes of the pond were inspected during normal pond inspections to determine the effectiveness of the seeding. As of Fall 1987, the revegetation effort appears to have been successful on the outslopes of the pond. Straw-bale dikes were added as necessary to control excessive gullying on the dam face. These dikes were installed as noted by Figure 7-11.

In addition to revegetating the outslope of the pond with the temporary grass seed mix, consideration was given to planting phreatophtes indigenous to the riparian community of Crandall Creek. However, the decision was made to not plant riparian vegetation for the following reasons:

- o The presence of deep-rooted riparian vegetation often encourages rodent burrowing, thereby reducing the stability of the dam.

- o Because the roots of phreatophytes are generally larger than those of grasses, roots of those riparian plants that die cause significant weakening of the dam upon decay.

- o R645 regulations require that interim revegetation of the pond embankment be conducted to stabilize the embankment "with respect to erosion". The plan proposed above (planting with grass species and installation of straw-bale dikes as necessary) will minimize erosion of the face of the dam due to overland flow. Erosion of the toe of the dam due to flood flows in Crandall Creek will be minimized with the addition of a layer of riprap along the toe as also outlined above.

7.42.30 Diversions

A diversion (UD-1) was placed along the western edge of the site at the location shown on Plate 7-5A to divert water from a 95-acre undisturbed watershed around the yard area. Analyses and design information associated with this and other existing diversions associated with the site are contained in Appendix 7-11.

The diversion was designed to safely pass the peak flow from the 25-year, 24-hour precipitation event. The resulting peak flow from this event (as noted in Appendix 7-11) was determined to be 47.7 cubic feet per second. This diversion is designed as a 42-inch full-round CMP. The diversion discharges onto natural boulders and water (during high flow of Crandall Creek) after passing beneath the U.S. Forest Service road to aid in energy dissipation. Details of the design are contained in Appendix 7-11.
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Table 7-7. Summary of slope stability analyses.

Cross Section[a]	Condition	Minimum Safety Factor	Required Safety Factor
A-A′	Unsaturated, static	2.20	1.50
	Unsaturated, seismic	1.76	1.10
	Saturated. static	1.19	1.00
B-B"	Saturated, static	2.00	1.50
	Unsaturated, seismic	1.56	1.10
	Saturated, static	1.08	1.00
C-C′	Unsaturated, static	2.23	1.50
	Unsaturated, seismic	1.67	1.10
	Saturated, static	1.38	1.00

[a] See Plate 7-4

Two additional diversions were designed to convey water from undisturbed areas away from the disturbed site. One (UD-2) was constructed in the northwest portion of the site along the proposed substation pad. The other was constructed in the northeastern portion of the site to convey water away from the portal area. Details of diversion design are presented in Appendix 7-11. Both of these diversions were designed to safely pass the peak flow resulting from the 25-year, 24-hour storm.

Existing and proposed culverts in the mine yard were examined to determine their adequacy with respect to passing the peak flow from the 10-year, 24-hour precipitation event. Details of these designs are provided in Appendix 7-7 and Appendix 7-11.

Similarly, ditches within the disturbed area were designed to pass the peak flow from the 10-year, 24-hour storm. Typical cross sections and design calculations are contained in Appendix 7-7 or Appendix 7-11 for these ditches.

A berm was placed around the proposed power substation to prevent runoff water that accumulates thereon from flowing across the remainder of the site. A small channel on the substation pad collects water from the pad and adjacent undisturbed areas. A stilling basin was placed at the downstream end of this diversion to trap sediment prior to discharging into UD-1 (see Appendix 7-7).

Plate 7-5A shows as-built surface runoff controls. Cross sections noted on Plate 7-5A are shown on Plate 7-5B. Appendix 7-7 contains calculations for proposed diversions and culverts.Appendix 7-11 contains as-built calculations for diversions and culverts. Watershed boundaries used in the as-built calculations for diversions and culverts are shown on Plate 7-5C.

7.42.40 Road Drainage

All of the Applicants roads have been designed, located and constructed as required by the regulations R645-301-742.410 through R645-301-742-423.5.

7.43 Impoundment

There are no permanent impoundments associated with the Applicant's facilities. Temporary impoundments of water collected for runoff control will occur in the sediment ponds. The physical design of the sediment ponds are certified designs as required in R645-301-512 and are presented in Section 5.33 of this application. The sediment ponds do not meet the criteria for MSHA regulations. The hydrologic design for the sediment ponds are presented in Section 7.42.20 and Appendix 7-10. On cessation and reclamation of mining and disposal activities, the sediment ponds will be removed.
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7.44 Discharge Structures

The sediment pond is equipped with a decant, a riser pipe (cmp) principle overflow and a rip-rapped open-channel emergency spillway. Sediment pond details are covered under Section 7.42.20 and in Appendix 7-10.

7.45 Disposal of Excess Spoil

No significant excess spoil will be developed by the underground mine. The only anticipated spoil will be from the materials collected in the sediment ponds. This limited volume of material will be removed from the ponds and transported to an approved refuse disposal area.

In the event spoil is generated during the mining operations, this will be transported to an approved disposal site.

The handling of these materials will comply with R645-301-745.

7.46 Coal Mine Waste

The disposal and placement of any refuse materials will be conducted in accordance with the plans presented in Chapter 5 of this application.

7.47 Disposal of Noncoal Mine Waste

Garbage

Solid waste generated from mining activities, such as garbage and paper products, is disposed of in large trash "dumpsters" located near the portal. A contract garbage hauling service, empties the contents of the dumpsters on a weekly basis and hauls the garbage to an approved dump or landfill.

Unusable Equipment

All salvageable mining equipment is sold to local scrap dealers: items such as broken bolts, worn out engine parts, and items which might be recycled. Any machinery or large parts are placed in a stockpile near the material storage area for periodic salvage by local scrap dealers. No mining equipment will be merely abandoned.

Petroleum Products

Oil and grease wastes are collected in tanks and returned to distributors for refining or used as heating fuel. In case of spills, a spill control plan has been developed and is located at the mine site.

7.48 Casing and Sealing of Wells

Following completion of reclamation, the monitoring wells for the mine site will be plugged and abandoned in accordance with R645-301-631 and R645-301-748. This will prevent the potential for disturbance to the hydrologic balance.

7.50 Performance Standards

All coal mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302. For the purpose of SURFACE COAL MINING AND RECLAMATION ACTIVITIES, operations will be conducted to assure the protection or replacement of water rights in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302.

7.51 Water Quality Standards and Effluent Limitations

Discharges of water from areas disturbed by coal mining and reclamation operations will be made in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining promulgated by the U.S. Environmental Protection Agency set forth in 40 CFR Part 434.

7.52 Sediment Control Measures

Sediment control measures will be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-760.

7.52.10 Siltation Structures

Siltation structures and diversions will be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-763.

7.52.20 Road Drainage

Roads will be located, designed, constructed, reconstructed, used, maintained and reclaimed according to R645-301-732.400, R645-301-742-400, and R645-301-762 and to achieve the following:

7.52.21 Erosion Control or Prevention

Control or prevent erosion, siltation and the air pollution attendant to erosion by vegetating or otherwise stabilizing all exposed surfaces in accordance with current, prudent engineering practices.

7.52.22 Suspended Solids

Control or prevent additional contributions of suspended solids to steam flow or runoff outside the permit area.

7.52.23 Effluent Standards

Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under R645-301-751.

7.52.24 Surface and Groundwater Systems

Minimize the diminution to, or degradation of, the quality or quantity of surface and groundwater systems.

7.52.25 Normal Water Flow

Refrain from significantly altering the normal flow of water in streambeds or drainage channels.

7.53 Impoundments and Discharge Structures

Impoundments and discharge structures will be located, maintained, constructed and reclaimed to comply with R645-301-733, R645-301-734, R645-301-743 and R645-301-745 and R645-301-760.

7.54 Disposal of Excess Spoil, Coal Mine Waste and Noncoal Mine Waste

Disposal areas for excess spoil, coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed to comply with R645-301-735, R645-301-736, R645-301-745, R645-301-746, R645-301-747 and R645-301-760.

7.55 Casing and Sealing of Wells

All wells will be managed to comply with R645-301-748 and R645-301-765. Water monitoring wells will be managed on a temporary basis according to R645-301-738.

7.60 Reclamation

Sealing of Mine Openings

The Applicant has drilled from the Hiawatha seam upwards to the Blind Canyon seam as described in Chapter 6. The drilling occurred in areas that pillar extraction will occur and no provisions were made to seal the bore hole.

Temporary sealing of the portals, if needed, will be accomplished by the construction of protective barricades or other covering devices, fenced and posted with signs indicating the hazardous nature of the opening. Permanent closure plans will include sealing the portals as per the request of the U.S.G.S. (See Section 5.29).

Upon cessation of mining operations all drift openings to the surface from underground will be backfilled, regraded and reseed as per Section 5.40 of this plan. Prior to final sealing of any openings, the U.S.G.S. will require an on site inspection and a submission of formal sealing methods for approval. The formal sealing methods will be presented as a plan including cross sections demonstrating the measures taken to seal or manage mine openings will comply with R645-301-529.

Permanent sealing of the portals will be done as shown in Section 5.29. A drain will be placed in the western most portal, this drain will be 18" deep 10' wide and extend under the backfill to the highwall. This drain will be redesigned if the mine produces greater quantities of water than anticipated.

Removal of Surface Structures

All waste material generated from the removal of the structures will be removed from the property and sold as scrap or disposed of in the appropriate approved state disposal areas, which at the present time will be the Sinbad landfill. The only structures to remain after the mining operation will be the sedimentation system and all necessary diversions required to insure routing of all disturbed area drainage to the pond and diversions to maintain the integrity of the pond until the requirements are met, these diversions can be found on Plates 5-16 and 7-5.

Upon cessation of mining operations, the water supply well (MW-1) will be permanently abandoned in accordance with regulations promulgated by the Utah Division of Water Rights. This will include filling of the well with a neat cement grout in accordance with the regulations.

Disposition of Dams, Ponds and Diversions

Upon final cessation of mining the area will be reclaimed. Upon completion of the reclamation earthwork the sediment pond will be cleaned out and the material disposed of in the approved method. Once it is determined that the pond is no longer required for sediment control of the reclaimed area, a the pond will be cleaned out again. The material in the pond should only be topsoil that has eroded from the reclaimed site, (care will be taken not to mix the pond liner with this topsoil) this topsoil will be stockpiled and allowed to dry at the edge of the pond. Once the topsoil has been dried the sediment pond will be reclaimed and the topsoil spread on top of the pond area.

Recontouring

All areas affected by surface operations will be graded and restored to a contour that is compatible with natural surroundings and post mining land use as near as possible to the contour of the land prior to disturbance by our mining operations. See map included with Vegetation and Terrestrial Wildlife Report included as Appendix 9-1 in Chapter 3. For approximate contours prior to our surface disturbance refer to the maps presented as Plates 3-7, 3-8 and 3-9. The final regraded contours can be found on Plate 5-17.

Removal or Reduction of Highwall

Backfilling and grading will proceed so as to eliminate or reduce the highwall. This can be by recontouring as per Section 5.40 of this Plan. The portals will be backfilled with soil and two rows of solid concrete blocks placed across each entry and then backfilled to the surface and recontoured as shown on Plate 5-17. The highwall above the coal stockpile will be backfilled with as much material as is available, however a substantial highwall will exist and a small flat spot will be left as a potential campsite.

Terracing and Erosion Control

No terracing will be done. All final grading, preparation of overburden before replacement of topsoil will be done along the contour to minimize erosion and instability unless this operation becomes hazardous to equipment operators in which case the grading, preparation and placement in a direction other than generally parallel to the contour will be used.

Final Reclamation

All areas affected by surface operations will be graded and restored to a contour that is compatible with natural surroundings. All final grading will be done along the contour to minimize erosion and instability unless this operation becomes hazardous to the equipment operators. Backfilling and grading will proceed so as to eliminate or reduce the highwall. Refer to Plates 5-16 and 5-17.

The outslope between the road and Crandall Creek will be supplemented with the planting mix.

Backfilling and grading will be done according to the reclamation timetable as originally submitted.

If possible, the topsoil will be redistributed in the late fall (late September or early October) just prior to the seeding time so as to have a seedbed free of weeds and annual grasses. If the seedbed is prepared early and weeds and annual grasses become established on it before seeding, they will be removed before seeding is attempted, refer to Chapters 2 and 3. Seeding will be done as soon as possible after the seedbed is prepared, but not prior to October 1st. If this cannot be done within 30 days, the Division will be notified.

On slopes of 30% or less a straw mulch of 1.5 tons per acre will be used to retain enough moisture for seed germination. The sloped greater than 30% will require a hydro-mulch of one tone of wood fiber mulch per acre. The wood fiber mulch shall be suspended in water to form a slurry type material and shall be sprayed evenly over the area where it is to be applied after seeding is accomplished. The straw mulch will be applied to slopes less than 30% and anchored into the soil by pulling a notched disc over the straw cover which results in pushing the straw ends into the soil. On slopes of 30% or greater, the ground will be hydroseeded, then mulched with one tone of wood fiber hydro-mulch with tacifier added to the mulching process. Any woody plant seedlings will be planted in small depressions on the slopes. No attempts at irrigation will be made during final reclamation.

Typical cross sections and topographic maps which adequately represent the existing land configuration of the area affected by surface operators are shown on Plates 3-7, 3-8 and 3-9. Postmining reclamation cross sections and surface topography will be as near to premining as is possible and practical as noted on Plate 5-17.

A reclamation map showing post construction contemporaneous reclamation areas and final reclamation accompanies this document as Plate 7-16 and 5-17 respectively. Slope rounding on Plate 5-3 has been revised to meet the required slope of 1.5:1 at the specified reclaimed cross sections. Two distinct areas showing post construction contemporaneous reclamation and final reclamation can be found on Plates 7-5.

One seed mix has been developed for all disturbed areas, made up of native and naturalized grass, forb and shrub species (see Appendix 3-15). Trees will be planted in the wooded areas and riparian zone.

Slopes of 30% or less and flat areas will be seeded with a rangeland drill equipped with depth control flanges on the discs. Row spacing will be 12 inches.

Appendix 3-15 includes a list of grasses, forbs, shrubs and trees to be used after December 1988 for both interim stabilization of topsoil stockpiles and for reclamation. This list was compiled by Lynn Kunzler in conjunction with the USFS. If changes in the seed mixture become necessary due to over- or undergrowth, seed availability, etc., all parties involved will come to an agreement as to the right seed mixture for each area.

Slopes of 31% or greater will be broadcast seeded using a hydroseeder prior to mulching. Wherever possible, the seed will be harrowed in before mulching is applied. The seed must be high quality seed (high % of germination, with weed seed content at a minimum and without any noxious weed seeds).

Refer to Plate 5-16 and 5-17 for the areas to be planted with planting mixture. Two tenths of a pound per acre of Louisiana Sagebrush (artemisia ludoviciana) could be added if needed for erosion control.

Concerning the revegetation of slopes 31% or greater, these slopes will be hydroseeded, then mulched with one ton of wood fiber hydromulch per acre.

No attempts will be made to establish rabbitbrush or sagebrush as previous experience has shown that it is impossible to stop these shrubs from invading the area on their own. If plants of snowberry do not establish from the seeding at the end of the second year,hand plantings of tubular started plants from native plant nurseries will be planted randomly on approximately one rod intervals where they occurred in the original land cover of the disturbed areas.

Trees, species and rates, to be planted on the slopes of 30% or less (in conjunction with the seed mixture (see Appendix 3-15).

The willows will be planted within 20 feet of the drainage to assure sufficient moisture for growth. The standard for the tree seedlings will be planted at the rate of 610 seedlings per acre. When considering a normal morality rate, this would establish the required 90% of the USFS recommended density standard of 550 trees per acre.

The seeding rates used are average for the seeding method used. It is hoped that the shrub seeds in the seeding mixtures will take hold and give a random spacing of plants over the area. If the seeded shrubs do not take, then the tublings will be planted in clumps. While clumping will not give a uniform seed dispersal over the entire area it would enhance wildlife habitat at little cost.

Species diversity standards have been established for revegetated areas. These will insure that a good mix of grasses, forbs, shrubs and trees, where appropriate, will be re-established, and that the reclaimed area will not be dominated by one or two species. The applicant has committed to protecting revegetated areas and to managing the reference area in a manner compatible with postmining land use.

The U.S. Forest Service, U.S. Fish and Wildlife Service and DOGM have requested that the riparian habitat be restored along Crandall Creek. The proposed seed mix and planting mix should accomplish this goal.

Applicant hereby commits to avoid the use of persistent pesticides and chemicals and to prevent fires.

Should lack of precipitation cause the vegetation to fail, all areas will be revegetated. No attempts will be made at irrigating the revegetated areas during final reclamation. The species recommended for revegetation are known to survive in this region without artificial application of additional water.

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